

ULTIMATE RACIAL INEQUALITY
How millions of early deaths distort politics

NewScientist

WEEKLY May 9 - 15, 2015

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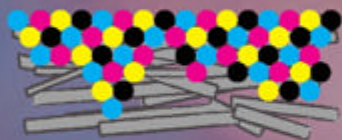


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How health inequalities distort democracy



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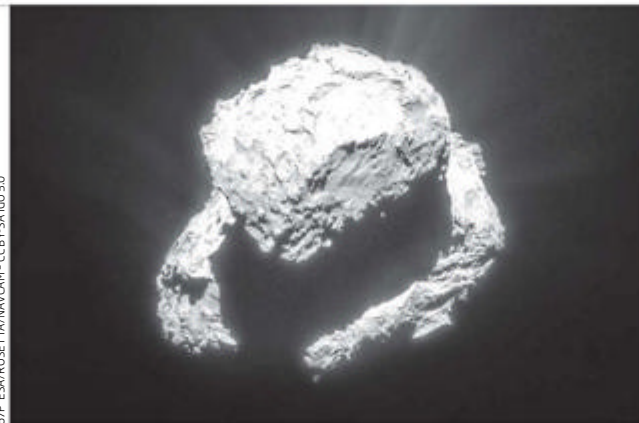
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Making the world better

Ebola has exposed the WHO's fatal weaknesses – again

HOW the world has changed. In 1948, the first commercial jet airliner was still a few years away from take-off, and the global population was just over 2 billion. Less than one-third lived in cities. Back then, safeguarding global health seemed an eminently manageable project. The newly formed United Nations agreed, and established the World Health Organization.

Now, over half the planet's 7 billion people are packed into urban areas. Between us, we travel tens of billions of kilometres around the globe every year, with plenty of pathogens and parasites coming along for the ride. The WHO, largely unchanged since its creation, is ill-equipped to deal with the disease threats that this new world creates.

The recent Ebola outbreak is a case in point. Even the WHO's director-general, Margaret Chan, said her organisation was "overwhelmed" and admitted that a crisis on that scale "cannot be solved by a single agency".

Those are chilling words. Shocking and scary as it is, the Ebola crisis has actually been relatively small: 26,000 cases across six countries. The prospect of something much bigger is very real (see page 30). A variant of the influenza virus is the most likely

immediate threat, but as the emergence of Ebola, SARS, MERS and others shows, there are plenty of other nasties waiting in the wings. As things stand, we are horribly exposed to the worst-case scenario.

Even more chillingly, we have known as much for a long time. Four years ago, a WHO review of the 2009 swine flu outbreak

"Shocking and scary as it is, West Africa's Ebola outbreak has actually been relatively small"

concluded that "the world is ill-prepared to respond to a... global, sustained and threatening public-health emergency". The review recommended a string of reforms, including a contingency fund of at least \$100 million to respond to similar global emergencies.

The WHO is finally taking those lessons on board. In response to the Ebola failures, Chan has called for sweeping changes, including the creation of an army of doctors and other health workers ready to be deployed in the case of an emergency, backed by the contingency fund. Later this month, at the World Health Assembly in Geneva, Switzerland, member states will vote on her suggestions for reform.

A yes vote is a no-brainer, but is not enough: \$100 million is insufficient to contain a medium-sized Ebola crisis, let alone a global pandemic of flu or some other airborne killer. "More funding" is an easy answer to difficult problems, but in the WHO's case this is genuinely and urgently required. Of its \$4 billion annual budget, about \$3 billion comes from philanthropic organisations or non-mandatory donations from governments – often with strings attached, such as being ring-fenced for a donor's pet project rather than spent on the WHO's own priorities.

The WHO is therefore operating more like an NGO than the global guardian of public health. Chan needs to persuade governments that their mandatory donations should be increased.

The WHO has an illustrious past – most famously the eradication of smallpox, but also less headline-grabbing successes such as reduced infant mortality. It can still play a vital part in global public health. However, it needs reform, and needs it now. Swine flu was a wake-up call, but the world fell back to sleep. Ebola is another, more urgent call. This time we must all hope that the WHO – and its funders – are not allowed to hit the snooze button. ■

Nepal's cholera shots

FIRST the quake, now the disease. The earthquake in Nepal on 25 April drove 2.8 million people into tents with little clean water or sanitation. Infections like hepatitis and diarrhoea are now occurring, but the biggest fear is cholera. It hasn't appeared yet, but it hits Nepal every rainy season. Those rains are due in June.

However, help is on the way. Nepal has an emergency vaccine to try to head off cholera – a first for a natural disaster. This is because of a vaccine stockpile set up in response to the cholera that struck Haiti after an earthquake in 2010 – cholera carried there, ironically, by Nepalese UN peacekeepers.

It will be no panacea: cholera experts stress that supplying clean water and toilets, and isolating and

treating any cases, are still essential. But Nepal has 18,000 doses of Shanchol, an oral vaccine made of dead cholera bacteria by Shantha Biotechnics of Hyderabad, India.

For full immunity you need two doses, two weeks apart, so there is only enough vaccine for 9000 people – and it will be difficult to ensure people in camps get both doses. In a final hurdle, the vaccine must be refrigerated.

The World Health Organization, other agencies and the Nepalese government will assess where people are least likely to get clean water in coming weeks, and where vaccination has the best chance of success, says Dominique Legros of WHO. More vaccine can then be flown in from the WHO's 2 million dose stockpile.



Thirsty, but is it clean?

Costly heatwaves

HOT weather has a high price. Heat stress costs the Australian economy US\$6.2 billion a year – showing what other countries might face where global warming is set to make extremely hot days more common.

Kerstin Zander from Charles Darwin University in Darwin, Australia, and colleagues surveyed 1726 employed Australians and found they reported taking an average of 4.4 days a year off work because of heat stress. Also, 70 per cent said that heat had made

Together this amounts to roughly 0.4 per cent of Australia's GDP. That's greater than the cost for Australia to cut its net carbon emissions to zero by 2050, estimated at as little as 0.1 or 0.2 per cent of its GDP. "The figure is quite conservative," says Zander; the researchers used lost income due to heat as a proxy for the decline in a person's economic output, but many people are underpaid for their contribution to the economy, she says.

Zander says that as the climate warms, the costs of particularly hot days might be greater in cold countries because they're not used to hot weather. "Australia was already hot, so we are [better] adapted," she says.

"This study shows heat stress is already responsible for about as much lost productivity as general illnesses," says Steven Sherwood from the University of New South Wales in Sydney, Australia. He suspects that as the climate gets warmer under expected climate change scenarios, this will have a significant impact alongside other better-known economic impacts of global warming.

"Heat stress is already responsible for about as much lost productivity as general illness"

them less productive on at least one day in the past year, with one-third saying it often did so.

The team calculated that heat-related absenteeism is costing the country US\$845 per citizen per year. Loss of productivity at work costs even more: US\$932 a head (*Nature Climate Change*, doi.org/4bf).

Ice men go missing

TWO experienced Dutch researchers are missing, presumed drowned, in the Canadian Arctic, 200 kilometres south of Bathurst Island. Marc Cornelissen and Philip de Roo were collecting data on ice thinning for the research organisation Cold Facts, set up by Cornelissen in 2010 after a crowdfunding campaign.

Cornelissen talked of "tropical" conditions in his last dispatch on Tuesday 28 April, joking that

the heat forced him to ski in underwear. "We think we see thin ice in front of us, so we're going to research some more of that if we can," he said. Two days later, the Dutch base camp received an emergency message by tracer.

A rescue helicopter spotted equipment and a dog at the location of the sent message, by a large hole in the ice, but conditions were too hazardous to land. Early the next day, police said the pair were presumed drowned. The dog, Kimnik, was rescued on Saturday.

Surprise launch

EAT your heart out, Bond villains. On 29 April, Amazon founder Jeff Bezos secretly launched an uncrewed rocket to the edge of space from his private launch facility in the Texas desert.

Bezos's rocket company, Blue Origin, has been working on suborbital space flight since 2000, with an eye on the space-tourism market. Its New Shepard capsule and booster rocket system have been developed under a shroud of

secrecy, with only a few short-range tests and one failed launch so far.

The company's latest test was much more successful, powering to Mach 3 speeds and reaching a height of 93.6 kilometres.

Once the rocket finished firing, its capsule was released, slowed by parachutes and returned safely to Earth.

The capsule is capable of carrying six people but was empty for this launch.

Printed rhino horn

A 3D-PRINTED rhino horn is making its debut next month, and could be on sale by August. The idea is to flood the market with synthetic horns in an effort to stem the number of rhinos killed.

KIM TAYLOR/NATUREPL.COM



Salamanders succumb, newts next

Newts on alert

A SKIN-EATING fungus that has wiped out 95 per cent of the salamander population in Belgium and the Netherlands has arrived in the UK.

The fungus, *Batrachochytrium salamandrivorans* (Bs), which was discovered in 2013, has killed four captive salamanders imported to the UK. Researchers have warned that if it escapes into the wild, it could decimate the population

"It's critical that no animals potentially carrying the fungus are released into the wild"

of great crested newts, a species native to the UK (*Veterinary Record*, doi.org/4bm).

Bs is a chytrid fungus related to *B. dendrobatidis*, which has been wiping out frogs and toads around the world. It has also been found in the UK, but does not seem to have harmed native frogs and toads. Given that Bs has already been shown to kill great crested newts, its arrival is potentially more serious.

"It's critical that no animals potentially carrying [the fungus] are released into the wild, which is illegal anyway," says Matthew Fisher from Imperial College London. "Likewise, water and organic matter from collectors

and hobbyists shouldn't be dumped down sinks or in gardens without disinfection."

The great crested newt is relatively abundant in the UK, Fisher says. Ironically, that makes the species more vulnerable because the disease could potentially spread more easily than it would if only isolated colonies existed.

Pluto's polar cap

LAND ahoy! About 80 days before it makes its closest approach to Pluto, NASA's New Horizons spacecraft can finally see surface features on this tiny world – including what may be an ice cap at its pole.

New Horizons launched in 2006, just months before Pluto was designated a dwarf planet. Previously, our best images of this distant world came from the Hubble Space Telescope, which saw it as a smeary orange blob.

Now, New Horizons' Long Range Reconnaissance Imager (LORRI) has captured pictures just slightly better than Hubble's – although the rocky world still looks pixelated. Most intriguing is one bright pixel that showed up in the same place in every image. "It's suspiciously suggestive of a polar cap," says mission leader Alan Stern of the Southwest Research Institute in Colorado.

60 SECONDS

Dreamliner says no

Switching it off and on again is once again the cure for a tech mishap. The US Federal Aviation Administration has revealed that Boeing's 787 Dreamliner must be rebooted at least once every 248 days, or else a software bug could cause the plane to lose power. It's the latest in a string of problems for 787s, which were previously grounded due to overheating batteries.

Honey trumps money

Did your latest sugar hit leave you craving more? It might depend on the type you consumed. Fructose, the sugar found in honey and fruit, appears to make our brains more responsive to images of food than glucose, and people who drink fructose-rich drinks are more likely to choose high-calorie foods over money prizes (*PNAS*, doi.org/4bp).

Pebble-dashed rover

Ever had a pebble stuck in your shoe? Curiosity knows the feeling. The Mars rover has snapped a picture of a rock wedged between the ridges of its tyre. NASA isn't too worried – the rock shouldn't affect Curiosity's performance.

Sonar-jamming junk

At least 57 species of hawkmoth have developed the ability to jam the sonar signals of their bat predators by rubbing their genitals against their abdomen. These ultrasonic genitals evolved independently at least twice among hawkmoths, which have been in an evolutionary race against bats for some 60 million years (*PNAS*, doi.org/4bq).

Sleepwalking inherited

Here's an advance warning. If both you and your partner sleepwalked as children, your child is seven times as likely to go for nocturnal strolls as they would if neither of you did. Sleep terrors in early childhood are also a warning sign, found a study of nearly 2000 Canadian children (*JAMA Pediatrics*, doi.org/4bn).



Secret mission

BLUE ORIGIN

Black votes matter

The premature deaths of millions of black people skew US elections

MacGregor Campbell

DEAD men cast no votes. A new study has found that the premature death of millions of black voters in the US has affected the outcome of several elections.

"We are talking here about deeply entrenched biases and prejudices in the operation of the economic, political and socio-cultural system which place blacks at a severe and systematic disadvantage," says Chik Collins of the University of the West of Scotland in Paisley, UK. "It is a very well-founded challenge to the claims of America to be a 'decent' – let alone a 'democratic' – society."

Last week saw protests in Baltimore and across the US touched off by the death of Freddie Gray, an African American man who died of a spinal cord injury sustained in police custody. His death has now been ruled a homicide and six officers involved will face criminal charges.

Overall, in the US, the mortality

rate for blacks, across age and gender, is almost 18 per cent higher than the rate for whites.

But while Gray's and other high-profile killings make the headlines, the far greater cause of premature death of African American people are chronic and stress-related diseases, says Arline Geronimus of Stanford University in California. For example, the diabetes rate for black people is almost twice as high as for whites, and blacks have higher rates of cancer and heart disease.

"People have tabloid images of why there are so many black excess deaths, but those are only a small part," Geronimus says.

When one demographic group dies at a faster rate than another, it skews the makeup of the electorate in favour of the group with the better survival rates. Geronimus and her colleagues wondered what effect this might have on US politics.

To find out, the team looked at the 35-year period between 1970

and 2004, and asked how the outcomes of elections, including the 2004 presidential contest, might have been different if the mortality rate of black and white people had been equal.

Reversed outcomes

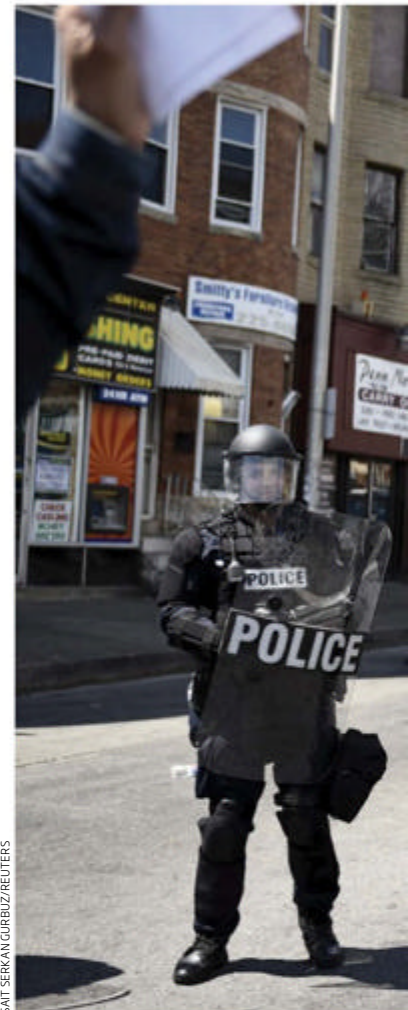
Using cause of death data from the US Centers for Disease Control and Prevention, Geronimus and colleagues calculated that if black people died at the same rate as whites, 5.8 million African Americans would have died between 1970 and 2004. The actual number of black deaths over that timespan was 8.5 million, meaning that African Americans had 2.7 million "excess deaths", compared with whites.

Of those 2.7 million, Geronimus and colleagues calculated that 1.74 million would have been able to vote in the 2004 elections, of whom 1 million would have actually voted.

The researchers then looked at how this extra million might have influenced elections, assuming they voted in line with actual black voters. African Americans tend to vote overwhelmingly for the Democratic party, so that party's presidential candidate, John Kerry, missed out on around 900,000 votes. Kerry's Republican opponent, George W. Bush, lost around 140,000.

The missing black voters alone would not have been enough to change the result – Bush was elected with a majority of more than 3 million votes. But the story is different at state level, especially if another cause of lost black votes is taken into account.

In 2006, Joe Manza of New York University and Christopher Uggen of the University of Minnesota estimated that 1.95 million voting-



SAIT SERKAN GURBUZ/REUTERS

age African Americans were unable to vote in 2004 because they'd been convicted of a felony.

Black people in the US are more likely to be arrested, convicted and incarcerated than whites. For example, a 2013 Pew Research Center study found that black men were six times as likely as white

"It is a well-founded challenge to the claims of America to be a decent – let alone democratic – society"

men to be incarcerated in 2010 – an increase from 1960, when black men were incarcerated five times as often as white men.

This meant that around 15 per cent of voting-age African Americans were excluded from

CLASS MATTERS IN THE UK

The US is far from the only country with differing mortality rates between groups. Chik Collins of the University of the West of Scotland in Paisley, UK, and colleagues have studied the effect in the UK, where the lines are drawn more by poverty and class than race.

Workers with routine and manual jobs, such as bus drivers and waiters, have the highest death rates, while managerial and professional workers like doctors and lawyers have the lowest, according to the Office for National Statistics. A 2011 study found that mortality rates in the five northernmost regions of England – which are generally poorer – were 13.8 per cent higher

than the four southernmost.

What this gap means for UK politics has not been explored in detail, although a 1996 study by George Davey-Smith of the University of Bristol and Danny Dorling of the University of Oxford found that people with lower mortality rates voting in elections in 1983, 1987 and 1992 were more likely to vote Conservative, while higher rates correlated with Labour votes.

Roughly 1.5 million – mainly working class – people might have voted in the 7 May election had they not died prematurely, Dorling says. Their loss also affects how many parliamentary representatives a city has, which is based on population.

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Politically powerful

the 2004 national election.

Geronimus's team calculated that seven senate and 11 gubernatorial election results would have been reversed had their hypothetical survivors been able to vote. These were close elections in which the margin of victory was less than a third of the number of estimated survivors in the state. Accounting for people disenfranchised by felony convictions could have reversed three other senate seats (*Social Science and Medicine*, doi.org/38j).

The team may have underestimated the number of excess deaths, Geronimus says. For one thing, they accounted for only 35 years, so missed out all excess deaths prior to 1970. They also don't account for any

potential children of those who died prematurely, who would have been old enough to vote in 2004.

This isn't just an issue in the US (see "Class matters in the UK", left), and it is the poor and marginalised groups that tend to lose out.

Remedying this inequality may be difficult, since the people who would vote for policies that might shrink the mortality gap – such as better access to healthcare – are also the ones likely to die prematurely, says Geronimus.

"If you're losing a voting population, you're losing support for the policies that would help that population," she says. "As long as there's this huge inequality in health and mortality, there's a diminished voice to speak out against the problem." ■

Long-lost relatives found at bottom of Arctic Ocean

SO THAT'S where they've been hiding. An entirely new group of organisms discovered at the bottom of the Arctic Ocean are our closest simple-celled relatives ever found.

Approximately 2 billion years ago, complex eukaryotic cells, which make up animals, plants and fungi, split from smaller, simpler cells called prokaryotes. Researchers have now identified our closest relatives from before this split.

Thijs Ettema at Uppsala University, Sweden, and his team discovered the new organisms when they analysed DNA extracted from underwater

"The Lokiarchaea are an entirely new group with sophisticated cellular functions"

sediment near Loki's Castle, a region of hydrothermal vents along the Arctic mid-ocean ridge (*Nature*, DOI: 10.1038/nature14447).

Named Lokiarchaea, the organisms are a new type of archaea. Like fellow prokaryotic bacteria, archaea lack a true cell nucleus and other complex cell machinery. But intriguingly, the Lokiarchaea appear to have more than 100 genes coding for sophisticated cellular functions such as deforming cell membranes and forming and transporting bubble-like vesicles around the cell – functions that are usually only seen in eukaryotes like us.

"It is a truly remarkable, landmark discovery," says Eugene Koonin at the National Center for Biotechnology Information in Bethesda, Maryland. It suggests that our sophisticated cells could have evolved from special, more elaborate forms of ancient prokaryote.

"We were really blown away when we got the first genome data," says Ettema. "We can now say that the archaeal ancestor of eukaryotes was perhaps already quite complex."

"Ettema's team have certainly thrown the cat among the pigeons," says Anthony Poole at the University of Canterbury in New Zealand. He says

that the discovery of Lokiarchaea blurs the lines between archaea and eukaryotes. "It's still 100 per cent archaeon, but the presence of genes we usually associate with eukaryote cell biology is absolutely fascinating."

Ettema's team argue that their finding helps bridge the gap between our cells and those of the typical prokaryotic organisms from which we are believed to have evolved.

Others are more sceptical. "We're getting closer to an archaeal ancestor of the eukaryotes," says Nick Lane of University College London. However, even though the Lokiarchaea are relatively complex compared with other known archaea, they lack the large genome and energy-producing mitochondria of true eukaryotic cells. "It's a thousandth of the way towards the complexity of a eukaryote," says Lane. So we can't really call them an intermediate step or a missing link.

Lane believes the crucial step in the evolution of the eukaryotes was acquiring mitochondria, which would have provided the energy to develop more complicated cellular processes and acquire a larger genome. Ettema does not think the Lokiarchaea have mitochondria, but he says some form of intracellular transport may have evolved before our ancestors acquired their powerhouses.

And while DNA data shows that the Lokiarchaea are our closest known prokaryotic relatives, they may still be very different from the common ancestor that we shared 2 billion years ago.

Unfortunately, we cannot know exactly how the Lokiarchaea use their genes until we can observe one of their cells directly. Ettema's team did not actually see the cells: they used computational methods to piece together the genomes from the DNA found in the seafloor sediment.

Archaea can be particularly difficult to collect and culture in a laboratory, so we may never get a good look at our long-lost prokaryotic cousins. Penny Sarchet ■

The man who sees with sound

Clare Wilson

WHAT is it like to be a bat? It's a question philosophers interested in consciousness like to ponder. Yet a few people already have something of a bat's world view.

Brian Borowski, a 59-year-old Canadian who was born blind, began teaching himself to echolocate aged 3. He clicks with his tongue or snaps his fingers as he moves about, unconsciously decoding the echoes. Although

"I store maps of information in my head. I compare what is in my memory with what I'm hearing around me"

many blind people get information from sounds around them, few turn this into a supersense by making sounds to help themselves get around.

"When I'm walking down a sidewalk and I pass trees, I can hear the tree: the vertical trunk of the tree and maybe the branches above me," says Borowski. "I can hear a person in front of me and go around them."

Borowski, who works as a programmer at Western University in London, Ontario,

suspects he experiences "images" in a similar way to people who can see, just with less detail. "I store maps of information in my head and I compare what I have in my memory with what I'm hearing around me," he says. "I am matching images of some sort." This probably isn't too far from the truth – we know from brain scans of Borowski and another echolocator that the strategy co-opts the same parts of the brain that usually deal with visual information.

For his latest scientific collaboration, he helped a team of researchers to explore how well echolocators can determine the relative sizes and distances of objects. Sighted people normally have no problem knowing whether objects appear small because they are far away or because they are actually small – yet both something small and nearby or large and distant would occupy the same area and angle in our field of view. "It's not a trivial thing," says team member Lore Thaler, at Durham University, UK. "But we don't think about it." So is it also easy for echolocators? You might think so, but previous work has suggested that echolocating



Tuning into the reverb

bats sometimes struggle.

Borowski, however, aced the tests, consistently identifying the true size of a range of objects placed at different distances. In contrast, 20 blind or blindfolded people who had no experience with echolocation floundered when asked to give it a try (*Neurocase*, doi.org/38g).

As for how he does it, Thaler points out that theoretically, echoes contain intrinsic information about the source's distance as well as its size, taking

longer to return from far-away objects. But Borowski feels he's using a different strategy. "If you're close to something, you hear a higher resolution. You get more detail," he says.

Human echolocation has attracted great interest since the late 2000s, when Californian Daniel Kish came to wide attention. Yet his organisation, World Access for the Blind, is still the only one that teaches the skill to others, and it is not generally taught to blind children in schools. Tom Pey of the Royal London Society for Blind People points out that most people who are blind or partially sighted lose their sight in later life, when their hearing might also be on the wane.

Thaler admits that echolocation has some drawbacks – it's not very good for detecting obstacles on the ground – but she is convinced it should be taught, and is currently helping Durham County Council to provide workshops. "It doesn't solve everything but it definitely gives additional information," she says. "It's an amazing example of brain plasticity." ■

HOW I LEARNED TO ECHOLOCATE

Once, when my parents were putting metal stakes into the ground, my brother – who is also blind – and I noticed that when they were banged with a hammer, the echoes bouncing off the house were really strong. We realised we could use that.

Playing games like hide-and-seek with our sighted brother honed our skills. His idea of hiding from us was standing in the middle of the lawn. At first we couldn't find where he was, but as we got better at echolocating,

he had to hide behind trees. We soon learned to find him there too.

Once we'd mastered the skill, we taught ourselves how to ride bikes. We didn't just use echolocation, but other things too to keep track of where we were: the slope of the road, whether the gravel was loose or well-packed. But we would always be clicking, listening for the grass growing at the side of the road, or for the turning into our driveway.

We never had any formal training.

Our teachers thought it wasn't a good thing to do. They said blind people have enough trouble fitting into society and you shouldn't do anything that causes you to be more different than you already are. But we more or less ignored them.

When I was younger I could get a lot of detail from echolocation. These days I can tell whether objects are large or small but I can't necessarily tell what they are. Brian Borowski, as told to Clare Wilson

Smart monkeys perfect tool use to crack nuts

CAPUCHIN monkeys from Brazil are famous for using hammers and anvils to crack open tasty nuts. Now it seems they do so with even more skill and judgement than we gave them credit for, rivalling skills of their brainy chimp relatives.

We knew the monkeys take care to select the best nuts and the best stones for cracking them. "What we've now shown is that this sophistication follows right through to the cracking performance itself," says Dorothy Fragaszy of the University of Georgia in Athens. "What we've found is important to the fundamental origins of human activities like this." Our own ancestors began making tools some 2 to 3 million years ago.

Fragaszy and her colleague Madhur Mangalam analysed videos of 14 bearded capuchin monkeys (*Sapajus libidinosus*) from southern Brazil cracking 181 tucum nuts. By noting how high each monkey raised the tool and the velocity with which the animal brought it down, they worked out the force used.

After each strike, the capuchins assessed the state of the nut to decide how much force to use next time, hitting the nut less hard if they had managed to breach the husk or

fails to breach the outer husk do they use more force next time.

Once they have peeled off the husk, the monkeys apply the same strategy to the inner shell. Easing up when making the final strike to remove the breached inner shell is important because too much force would wreck the edible nut inside. "It would just splat," says Fragaszy.

"The results put the capuchin monkeys in the same league as chimpanzees, who have also been shown to adapt their striking force to the hardness of nuts and the weight of their hammer," says Robert Rein of the German Sport University in Cologne.

"The evidence is now strong that wild bearded capuchins are not mindless robots performing a parody of human actions," says Michael Haslam of the University of Oxford.

"It's not a rote behaviour. The monkeys instead adjust their pounding actions, the same way a human might adjust the strength of their blows as they hammer a nail into a piece of wood."

Haslam's own study shows for the first time a female capuchin using a stick to probe her own nose to cause a sneeze, possibly to dislodge an obstruction. She also poked her teeth (*Primates*, doi.org/374). Males at the same site have been seen using sticks before, but only for dislodging otherwise inaccessible food.

"Despite their small body and brain size compared to humans or chimpanzees, capuchins are very inventive, and we likely have a great deal more to learn about the limits of that inventiveness," says Haslam.

But Guy Orban of the Catholic University of Leuven (KUL), Belgium, says that although impressive and groundbreaking, the capuchin's feat doesn't come close to matching early or modern human tool use, which involved imagining and designing new tools rather than learning to utilise readily available objects. "They lack the insight to find the perfect stone and keep it," he says. Andy Coghlan ■



Can I crack it?

Cuckoos and their victims: an evolutionary arms race

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"Capuchins adjust pounding the same way a human might adjust hammering a nail into a piece of wood"

shell (*Current Biology*, doi.org/4bh). "It involves monitoring of the state of the nut, then adjusting their strategy accordingly, using sensory and perceptual feedback," says Fragaszy.

Cracking the nuts is complex because to get to the soft edible part the monkeys have to get through an outer husk and then a much harder shell. "It's essentially a two-stage problem," says Fragaszy. "They initially strike with one degree of force, but when the outer, green husk has been breached, they then strike with less force." Only if the first strike

Microbe architects build live-in rocks

Colin Barras

THEY are, perhaps, the world's deepest architects. Microbes living beneath the sea floor near methane seeps construct extensive rocky deposits – and then live inside them. The organisms may be representatives of a distinct lifestyle that could be well-suited to conditions on harsh, alien worlds.

Our planet's crust is home to a surprising diversity of microbes, either living inside crevices in the sediments and rocks below Earth's surface, or burrowing their way through. But none are quite like the microbes Jeffrey Marlow's team at the California Institute of Technology in Pasadena have found below the seabed at methane seeps near Oregon.

These microorganisms oxidise methane and generate bicarbonate ions that help them build vast limestone slabs in the soft sediment. What makes them truly unusual, though, is their bizarre lifestyle: they seem to continue living inside cavities within the limestone they create. That life of self-entombment is so unlike anything else seen on Earth

that Marlow and his colleagues propose giving it a new name: such microbes should be called autoendoliths.

"Autoendoliths may be common on and below Earth's surface, essentially using chemical energy to build physical

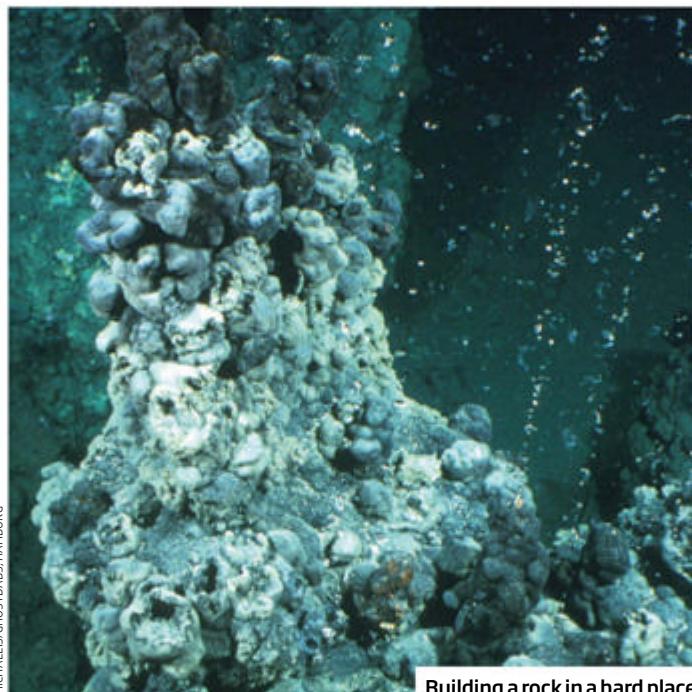
structures," says Marlow. We do not know yet how they relate to other bacteria and archaea, but they are likely to be from known evolutionary lineages, says Andreas Teske of the University of North Carolina at Chapel Hill. So, they may be relatives of microbes living around methane seeps that have adopted an unusual lifestyle.

We have known for decades that some microbes can build rocky structures, for instance, stromatolites. But these microbes live on or near the surface of the

rocks they make, where they have access to nutrients and light to photosynthesise and metabolise. Autoendoliths, in contrast, inhabit the deep interior of the rocks they build.

So why do they do it? In the case of the Oregon microbes, this lifestyle might provide an advantage in the form of a better energy source – methane-rich fluids bubble up and become more concentrated inside the rocks the autoendoliths create, says Marlow. But other autoendoliths might live deep inside the rock they build to escape harmful conditions nearer the surface, he suggests.

That might have implications for the search for life on Mars and other planets. Astrobiologists already suspected that if life exists on Mars, it probably moved deep underground to escape the intense radiation and extreme temperature swings on the Martian surface. An autoendolithic lifestyle could offer microbes closer to the surface a means to grow their own protective shield from radiation. There is evidence that some surface-dwelling microbes in high-altitude environments on Earth grow mineral coatings to protect themselves from the strong UV radiation there. "It could be seen as an evolutionary advantage in this sort of situation," says Marlow. ■



Building a rock in a hard place

Syria war hones our seismic image of bombs

A MAJOR incident during the Syrian civil war is helping to pin down the seismic signature of distant bombs.

Although seismologists have long monitored nuclear explosions, any nuclear tests since 1980 have taken place underground. Measurements of smaller, conventional explosions on or near the surface are relatively rare.

Accurate models of such blasts

could help interpret seismic readings and allow rescuers to deal with incidents in war zones or industrial accidents. "Knowing the yield and depth of large, shallow explosions is useful to government agencies from an emergency response perspective," says Michael Pasyanos of the Lawrence Livermore National Laboratory in California.

Working with colleague Sean Ford, Pasyanos added a dampening effect to existing models to account for how shallow seismic waves are weakened when they pass from the ground into the air. To do this, they used data from

controlled explosions at the US army White Sands Missile Range, New Mexico, in 2012 (*Geophysical Research Letters*, doi.org/38p).

They were also able to test and refine the new model using seismic readings from May last year, picked up when rebels blew up an army base in north-west Syria.

The model gave the cause of the explosion as a bomb equivalent to

between 6 and 50 tonnes of TNT, depending on the assumed depth. The rebels claimed to have used a 60-tonne bomb, so it is possible they were exaggerating or that the explosives were of poor quality and did not fully detonate.

How accurate the model will prove depends on knowledge of the local geology, says Sam Toon of Keele University, UK, but he thinks it will be useful. "With things like the rebels in Syria, it gives you an idea of the capabilities they've got, what kind of explosives they might have access to." Jacob Aron ■

"They tested the model on a large explosion last May, when rebels blew up a Syrian army base"

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A drug to treat cannabis addiction

Clare Wilson

IT IS considered a soft drug, but increasing numbers of people are seeking help for cannabis addiction – and there's growing interest in finding ways to treat them.

Paradoxically, the most promising treatment may be an extract of cannabis. Last month, researchers at the British Neuroscience Association meeting in Edinburgh, UK, described how the compound, called cannabidiol, helped one person who was severely addicted. A clinical trial is underway.

Unlike most forms of drug addiction, there are no medical

"The number of teenagers seeking treatment for addiction has risen 50 per cent in the past decade"

treatments to help people reduce their cannabis use. "Cannabis dependence is a huge unmet need with no pharmacological treatments," says Tom Freeman of University College London, who is involved in the trial. "It's vital we get one."

A possible connection between smoking pot and schizophrenia is fairly well known, but the link is controversial and it affects only a small minority of users. Addiction seems to be a more common problem – yet is often overlooked.

There is no universal definition of addiction or dependence. Someone is usually deemed to be addicted to a drug if they want to stop but cannot, or if it has a negative impact on their life. They would probably be experiencing withdrawal symptoms that make it hard to give up. In the case of heavy cannabis use, these can include anxiety and insomnia.

It is unclear how many marijuana users get hooked. A commonly quoted figure is that about 9 per cent of regular users become dependent, which probably stems from a US study from the 1990s.

This would make cannabis relatively non-habit-forming compared with other drugs – the same figure for heroin is 23 per cent and for alcohol is 15 per cent. Yet the risks of cannabis addiction are compounded because people think it is non-addictive, says Luke Mitcheson, who treats drug users at South London and Maudsley NHS Foundation Trust. "The perception is that it's fine, but we shouldn't underestimate its habit-forming potential."

What is less controversial is that the number of people looking for help with their cannabis use is on the up, especially among teenagers. In the past decade the number of under-18s seeking treatment for cannabis addiction has risen by 50 per cent. "People are coming for help and you can't argue with that," says Freeman.

This may be because the cannabis available is becoming more potent, with increasing levels of THC, the compound that gets you high. Prolonged exposure to THC leads to lower



Kick back: it's legal in Colorado

levels of the brain's natural version of this substance, a chemical called anandamide.

Levels recover after stopping the drug, but in the meantime there are withdrawal symptoms. That's why cannabidiol, another chemical in cannabis, might help as it boosts anandamide.

In 2012, doctors in São Paulo in Brazil suggested synthetic

cannabidiol as a treatment for a 19-year-old woman who had intense withdrawal symptoms whenever she tried to quit cannabis. She had smoked it daily since she was 13. Her symptoms eased within a day or two of taking cannabidiol, and she managed to quit. This suggests a way to help people through withdrawal, José Crippa of the University of São Paulo told the conference.

Freeman's team at UCL is doing a randomised trial comparing cannabidiol with a placebo in 48 people, expanding to 168 people if the first results are positive. "We shouldn't overstate the results of a single case," says Freeman. "But it's going to be exciting to see what happens with this study."

Another strategy being looked at is using THC itself as kind of substitution therapy, however Crippa points out this still leaves people addicted to THC. ■

GOING LEGIT

Cannabis is being legalised or decriminalised in a growing number of countries. Yet it has more potential for addiction than people realise (see main story).

That's no argument for keeping it illegal, says Danny Kushlick of Transform, a UK think tank that campaigns to legalise drugs. "Drugs need to be legalised and regulated precisely because they carry risks.

Why would you want to leave supply in the hands of organised criminals?"

Kushlick also points out that keeping cannabis illegal makes it less likely that people will seek medical help if they have trouble quitting, for fear of a criminal record. And at the moment, drug dealers make more money by selling the most potent kinds of cannabis, which probably increases the risk of dependency.



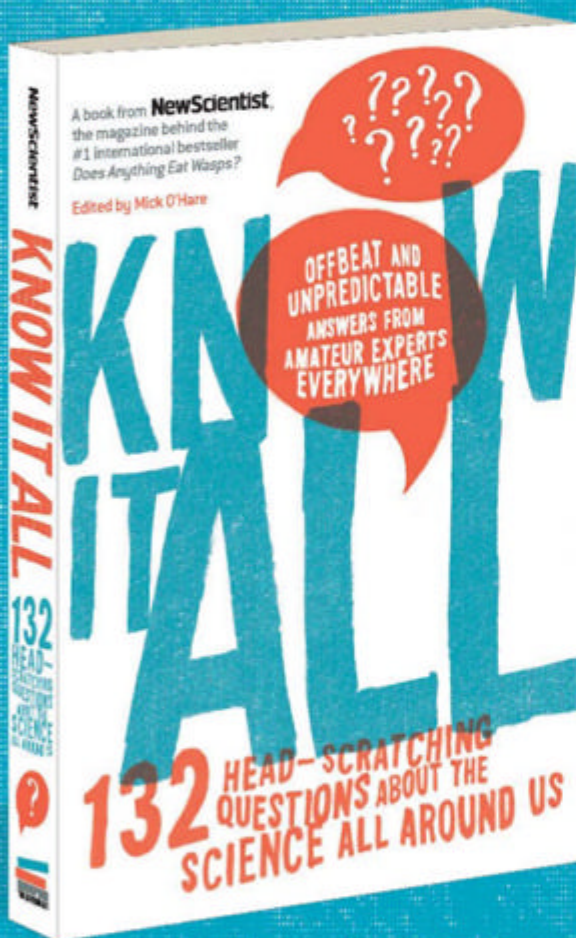
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Yum, yum, a gulp of nutritious womb milk

CALL it the milk of life – not breast milk, but womb milk. For the first 11 weeks of pregnancy, before the mother's nutrient-rich blood supply is plumbed in, all the materials for building a baby are supplied by secretions from glands in the uterus. We now know how these nutrients get from the glands into the developing embryo.

During pregnancy, the lining of the uterus behaves quite differently to normal: the glands store large amounts of glucose as glycogen, which is then secreted to provide nourishment. By comparing donated womb, placenta and embryonic tissue from different stages of

pregnancy, a team led by John Aplin of the University of Manchester, UK, was able to track the path of the glycogen. The researchers found it was abundant in the recesses of the womb lining, where it gets broken down into smaller molecules that get absorbed into the placenta.

They also tracked molecules called glycoproteins, which are broken down into amino acids – the building blocks from which tissue is assembled.

It's no accident that womb-milk secretions are the embryo's only source of nourishment in the first weeks of life, says Aplin. During this time, the growing embryo is so tiny that the pressure of the mother's blood could dislodge it from the wall of the uterus. Only after 11 weeks or so is it big enough to withstand and accept this blood, after which the secretions dry up (*Placenta*, doi.org/378).

Here I am, no over here, no wait...

BEAM me up. Teleporting people around a room is helping to reveal how our sense of self is created.

As we go about our lives, we experience our body as a physical entity with a specific location. To find out how the brain manages to do this, Arvid Guterstam at the Karolinska Institute in Stockholm, Sweden, asked 15 volunteers to lie in a brain scanner while wearing a head-mounted display.

The display was linked to a camera on a dummy body lying elsewhere in the room, which meant that the volunteers saw the room from its perspective. Stroking both the real and the fake body at the same time tricked the person's brain into the illusion of inhabiting the dummy's body and being at its location.

The experiment was repeated in different parts of the room and

brain activity analysed. One region of the brain, the posterior cingulate cortex, seemed to control both our sense of inhabiting our body and our sense of where we are in space.

"If we can figure out how the brain constructs the sense of body in space, it will give us clues as to what goes on in disorders such as schizophrenia – where there are disturbances of self-perception," says Guterstam (*Current Biology*, DOI: 10.1016/j.cub.2015.03.059).

Can you speak baby babble?

GOO, bah, waahhhh! Crying is an obvious sign something is up with your little darling but beyond that, their feelings are tricky to interpret – except at playtime.

Jitka Lindová at Charles University in Prague, Czech Republic, got 333 adults to listen to recordings of 5 to 10-month-old babies, made while they were experiencing a range of emotions.

The adults could almost always distinguish positive noises from negative, but could hardly ever work out the specific emotion. Playful sounds were an exception. The adults were able to correctly recognise sounds associated with play 65 per cent of the time.

While other sounds convey danger or satisfaction, playful sounds may represent a baby's attempt to elicit an interaction, says Lindová, perhaps explaining why they are easier to understand. "It is practice for communication" (*PLoS One*, doi.org/37b).

Dinosaur art shows impossible feat

COULD some of the biggest-ever dinosaur predators have paired up to carry their 1.9-tonne sauropod prey? Donald Henderson of the Royal Tyrrell Museum of Palaeontology in Alberta, Canada, set about finding out after seeing an artwork depicting two *Carcharodontosaurus saharicus*, theropod relatives of *T. rex*, carrying each end of a 10-meter-long sauropod in their 1.6-metre-long jaws.

His results? They could have balanced just fine, but their neck and jaw muscles would have been too weak for the feat. The pair could only have picked up 850 kilograms between them – about the mass of a large cow, but not a large sauropod (*The Anatomical Record*, doi.org/379).

Spider silk souped up with graphene

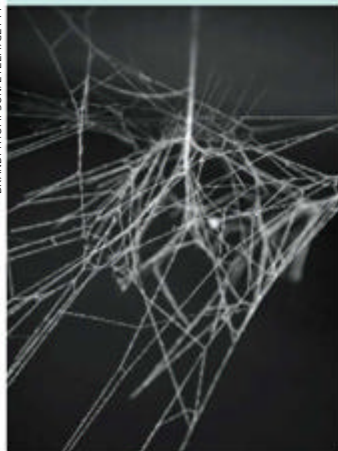
SPIDER-MAN would be so envious. Spiders have woven webs infused with carbon nanotubes and even graphene, raising the prospect of new materials with record-beating properties.

Graphene – sheets of carbon just one atom thick – is one of the strongest artificial materials, and spider silk one of the strongest natural ones. So Nicola Pugno of the University of Trento, Italy, wondered what would happen if you combined them.

Pugno and his colleagues captured five *Pholcidae* spiders, a common family, and sprayed them with a mixture of graphene particles and water. They also sprayed another 10 spiders with carbon nanotubes and water.

Some spiders produced below-par silk, but others got a major boost. The best fibres came from a spider dosed with nanotubes: it was around 3.5 times tougher and stronger than the best undoctored silk, spun by the giant riverine orb spider (arxiv.org/abs/1504.06751).

The team isn't sure how the graphene and carbon nanotubes end up in the silk, but Pugno believes the spiders mop up materials in their environment as they spin. This comes at a cost, however – four of the spiders died soon after being sprayed.



BRAND THOMPSON/VEEVA/GETTY

Fin whales' bungee-cord nerves are soooooo stretchy

SOME nerve! Stretch our nerves just a few millimetres and we recoil in pain – which makes a fin whale's bungee-rope-like nerves even more impressive. They can stretch to more than twice their normal length.

Robert Shadwick of the University of British Columbia in Vancouver, Canada, and his team stumbled upon a long, white cord, which looked like a blood vessel, while analysing whale tissue. Once they realised it was a nerve they were amazed at how far they could stretch it – something

unheard of in vertebrates. The stretchiness comes from a unique micro-coiling of the biological materials that make up the sheath of the nerve, especially collagen and elastin. The tiny coils unravel to allow the sheath to stretch, then return to their coiled state when the nerve contracts (*Current Biology*, DOI: 10.1016/j.cub.2015.03.007).

These enormous animals are lunge feeders, swallowing huge amounts of water, then filtering out the 2 tonnes of fish and krill they consume daily. A single

water intake may exceed the volume of the whale itself. "For this to work, they use a very expansible ventral cavity," says Shadwick. The cavity can only expand if its nerves and blood vessels do too. "The specialised nerves are one of the key anatomical components that had to evolve to make the system work," he says.

Only the nerves from the part of the body involved in lunge feeding were stretchy, which means they had evolved specifically for this task.

Galaxy pile-ups light up black holes

LOOKS like something left the lights on. The supermassive black holes at the cores of some galaxies give off a tremendous amount of light. It comes from superheated discs of gas that slowly spiral into the maws of the black holes, but the origin of the discs has been debated for decades.

One of the main hypotheses is that the gas could be funnelled towards black holes as a result of colliding galaxies sending vast amounts of gas toward their shared centre as they merge. To test whether this could be happening, Jueun Hong of Seoul National University in South Korea and colleagues imaged 39 of these bright active galaxies, capturing fine, faint details. They inspected the images for signs of a past or ongoing merger – wispy trails of stars flung violently into space during an intergalactic pile-up.

The team found that 17 of the galaxies had such features, which was between four and eight times more than they saw in a sample of non-active galaxies, leading the team to conclude that mergers are the main cause of the light from the brightest holes (*Astrophysical Journal*, doi.org/375).



PETER VRŠANSKY

100-million-year-old killer cockroach

IT'S OK, it's trapped. This exotic, praying-mantis-like cockroach that lived at the same time as dinosaurs was caught in amber about 100 million years ago. It is part of a newly discovered family of extinct predatory cockroaches.

Peter Vršanský, of the Geological Institute in Bratislava, Slovakia, and Günter Bechly, of the State Museum of Natural History in Stuttgart, Germany, say its long neck – which allowed the head to rotate freely – and unusually long legs suggest it pursued prey (*Geologica Carpathica*, DOI: 10.1515/geoca-2015-0015).

The fossilised insect, called *Manipulator modificaputis*, was discovered at a mine in Noije Bum, Burma. During the Cretaceous period when it lived, several predatory cockroach-like lineages evolved. Only one group survives today: praying mantises.

The specimen is one of dozens of preserved insects found in the area, making it the most important site of dinosaur-era amber, says Vršanský. Many pieces of amber contain complete adult insects, and they should help reconstruct the history of the animals and their ecosystem.

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Socially savvy, by email at least

No empathy? Fake it

Soon you'll have the tools to hone your online communication skills as well as figure out how to make the perfect first impression

Aviva Rutkin

IF YOU want me to respond to your next email, you should try adding an emoticon to it. Well, that's the sort of thing Crystal says I like.

Crystal Knows, a start-up in Nashville, Tennessee, calls its app "the biggest improvement to email since spellcheck". It is part of a growing suite of high-tech tools, some serious, some silly, that promise to help people talk to each other more effectively.

You tell the system who you want to contact and it then sifts

through what that person has posted online, mostly on social media and what comes up in a Google search. It then devises a list of recommendations, using methods borrowed from established tests that look at the Big Five personality traits, on how to style your emails to get the best response.

For an email to my editor, for example, Crystal suggests that I ditch the formal greetings and not bore him with anything he's heard before. With my girlfriend, it advises some self-deprecating humour. And for people reaching

out to me, it proposes adding an emoticon.

You can also choose to answer multiple-choice questions about a specific person ("If there was a conflict at work, how would he react?"). The software will use your answer to tweak its overall profile of an individual.

Crystal founder Drew D'Agostino thinks their algorithm can help people, particularly co-workers, strengthen their relationships with one another. "Everybody has some level of anxiety about sending email," he says. "Crystal is not helping

you to be like a robot and programmatically send emails. It's helping you to understand how people write."

Some other tools are a bit sillier. The Emotional Labor browser extension, built by New York City writer Joanne McNeil, will embellish emails with exclamation points, smiley faces and affectionate words – a spoonful of linguistic sugar added with a single click. Distracted men can download the BroApp, a program that automatically sends their girlfriends boilerplate texts like "Hey babe, how was your day?" and "Miss you".

Apps like Crystal touch on another modern problem: the sheer volume of messages we receive every day. One report from the McKinsey Global Institute estimated that some workers spend up to 28 per cent of their day sorting through emails. Another study, published last year, estimated that time their physicians wasted reading emails cost the Penn State College of Medicine \$1 million. The authors urged institutions like theirs to fight back against "our current metastatic email culture" by rethinking what emails are worth sending and whether people really want to receive them.

Research like this suggests we really need a way to contain the avalanche, perhaps with filters that are better at guessing which messages we really care about. Teller, a firm in Stockholm, Sweden, is working on an email

"The Crystal app can help co-workers strengthen their relationships with one another"

browser that will track users' behaviour, noting which emails they ignore and which they spend time on, and then decide which messages to shunt to the top of the inbox.

Charlie, a start-up based in Chicago, offers another way to

handle the internet's information overload. Instead of having to stalk people on Google before you meet, Charlie's artificially intelligent assistant will keep you briefed on new acquaintances. It combs through your Google calendar for upcoming meetings, scours the internet for background information on the people who will be there, and submits a one-page dossier before the meeting is set to start.

First impressions

Charlie makes it easier to make an impression on people, says co-founder Aaron Frazin. If the report mentions that a new client is a fan of the Chicago Cubs, you might find a way to casually mention baseball during the meeting. Or, if their company recently tweeted about a new product, you might remember to congratulate them on the launch.

"Technology is making communication quicker. That means we need to adapt and make sure that the beginning of the conversation is as effective as it can be," says Franzin.

He says the hardest feature for Charlie to nail is the list of people's personal interests, which can be difficult to figure out from a handful of Facebook posts or tweets.

But as our wealth of personal data grows, so too may the programs that decide what we want to hear, and what we should say. For now, the tools that are out there may be useful to those of us who don't have the sharpest people skills, says Jodi R. R. Smith, an etiquette expert at Mannersmith in Boston, though she cautions that what someone puts on Facebook or Twitter may not be an accurate reflection of their personality.

"Learning how people like to communicate, this is something that socially savvy people already do," she says. "But less emotionally astute people might find they're able to improve." ■

AI wears its best poker face to take on the pros

IT'S humans versus machine at the Rivers casino in Pittsburgh, Pennsylvania. Four professional poker players are squaring up to an artificial intelligence over two weeks, duking it out by playing a total of 80,000 hands of poker for a \$100,000 cash prize.

This may turn out to be the latest instalment in a grand tradition of computers beating us at our own games. In 1997, IBM's Deep Blue computer famously beat chess great Garry Kasparov. Four years ago, IBM's Watson took part in the TV quiz show *Jeopardy!* and crushed two contestants with a strong track record. AI has even mastered the popular smartphone game *2048*.

Still, poker is a tough nut to crack. In a game like chess, everyone knows where all the pieces are on the board. By contrast, poker is a game of imperfect information: players don't know for sure what cards the others hold or what will come up next in the deck. That makes it a challenge

for any player, human or computer, to choose the right play.

Computer scientists have already made some progress, at least with simpler forms of the game. But the version being played at the Pittsburgh tournament, called Heads Up No Limit Texas Hold 'em, is "a completely different beast", says pro player Vanessa Selbst. "There's much more human elements and game strategies to employ, so it's a much more complex game." What's more, there are no betting limits, so the computer also has to take into account how much players might stake on each game.

Competing in Pittsburgh is Claudico, a program created at the city's Carnegie Mellon University. Claudico taught itself poker skills by playing trillions of games in search of some kind of optimal strategy. Whatever it has picked is pretty good: last year, Claudico beat all 13 other computer competitors at no-limit poker in the annual contest run by the Association

for the Advancement of Artificial Intelligence.

Computers have a few edges over humans, says graduate student Noam Brown, part of the team behind Claudico. For example, a computer can switch randomly between various betting strategies, which may confuse human opponents.

On the other hand, Claudico is slow to pick up on and adapt to people's playing styles - something that many pro players do with ease. "One of our big concerns is that the human will be able to identify weaknesses that Claudico has and exploit them," says Brown.

Because Claudico taught itself to

"We're putting our faith in our program. It knows what it's doing much better than we do"

play, even the team that built it don't quite know how it picks its moves. "We're putting our faith in Claudico. It knows much better than we do what it's doing."

Algorithms like those used to play poker could be valuable for other kinds of problems characterised by imperfect information. They could suggest optimal locations for military resources in a war, for example. Rival AIs could also be tasked to negotiate with each other over insurance rates or handle legal squabbles. "In society, sometimes you see one side getting screwed over because someone has more lawyers or more information or more resources at their disposal," says Brown. "Something like this can really level the playing field."

The winner of the poker tournament won't be crowned until the event ends on 7 May. Eric Jackson, a software engineer who creates poker bots as a hobby, is cautiously optimistic that Claudico can win. As we went to press, the pros and Claudico were neck and neck.

Even if AI triumphs, it won't mean programmers have conquered the game. "Beating humans decisively would be a landmark, but it wouldn't mean the end of work on poker," says Jackson. "We still don't know what the perfect strategy is." Aviva Rutkin ■



OK computer, let's see you do this

KATARINA LOFGREN/MASKOT/PLAINPICTURE

INSIGHT Military clothing

The invisible soldier

Can metamaterials hide someone from view, asks **David Hambling**

The US army wants invisibility cloaks for its soldiers. Not just that – it has announced that it wants to test the best contenders within the next 18 months. Seems a bit unrealistic? Well, we may not be as far away as you think.

In 2006, John Pendry, a theoretical physicist at Imperial College London, showed that it should be possible to bend light around an object and hide it using metamaterials – structures engineered at microscopic levels to channel electromagnetic waves. Since then, many devices trumpeted as invisibility cloaks have been described, but they only work in the lab with specific wavelengths or from certain angles.

Now the US army has made a call for proposals from companies for wearable camouflage with a chameleon-like ability to change according to the background. So how

will they manage this? Metamaterials are probably the best solution: previous efforts in this field using technology like LEDs were hampered by power and computing requirements.

But although they can bend light, metamaterials cannot make things disappear completely.

“Complete invisibility of macroscopic objects for all visible colours is fundamentally impossible,” says Martin Wegener of the Karlsruhe Institute of Technology in Germany. His team has created cloaks from photonic crystals that work for certain wavelengths, but bending light over the entire spectrum is forbidden by relativity.

“This means that you may see less of something at a particular colour, but see it at all other colours,” says Wegener.

The wearer would be effectively transparent at some wavelengths but

not all, rendering them as a coloured shadow or ghost image.

Contractors will demonstrate the feasibility of their approach in the first six months of the programme. Those selected for the following one-year phase will submit 10 prototype uniforms for testing. These need to work in all terrain from all angles. They also need to function across a wide range of temperatures, in rain

“Metamaterials might be used to generate adaptive camouflage patterns rather than for cloaking”

and snow, and without hampering a soldier's normal duties.

If the adaptive camouflage requires a power source, this must weigh no more than 0.45 kilograms and provide at least 8 hours of operation.

Some firms claim to be on their way there already. Guy Cramer, CEO of Canadian camouflage makers Hyperstealth Biotechnology, says he demonstrated metamaterial camouflage to US military scientists last year, and that the new project will allow him to move forward with it. But Cramer won't yet reveal details or release photographs of the material.

Metamaterials might be used to generate adaptive camouflage patterns rather than for cloaking, suggests Andrea di Falco of the University of St Andrews, UK.

The new specimens will be compared with existing camouflage patterns using standard NATO tests, indicating that something less than complete invisibility is expected.

However, as Wegener points out, the word “invisible” can mean different things. If the wearer looks like a shadow among other shadows and cannot be identified as a person, they may be invisible enough for military purposes. ■

ONE PER CENT



These pants are bugging me

Never mind ants in your pants, what about glowing bacteria? Designed by Neri Oxman at MIT, and 3D-printed by Stratasys, these extravagant garments are actually artworks called *Mushtari*. Inspired by our gastrointestinal tract, the articles of clothing are filled with liquid containing cyanobacteria and *E. coli*, which fluoresce in bright colours.

“Everyone's worst day is now going to be put on YouTube for eternity”

Police chief **Steven Strachan** of Bremerton, Washington, tells *The New York Times* about the possible negative consequences of body cameras worn by police

Wonder wall

Time to power up. Tesla has announced its latest product: a huge battery you fix to the wall of your house. The Powerwall costs \$3500 for the 10 kilowatt-hour version, and it stores power generated by a home's solar panels during the day when demand is low so you can tap into it in the evenings. The battery itself is lithium-ion, just like the one in your smartphone, and it is liquid-cooled.



Lurking in the shadows

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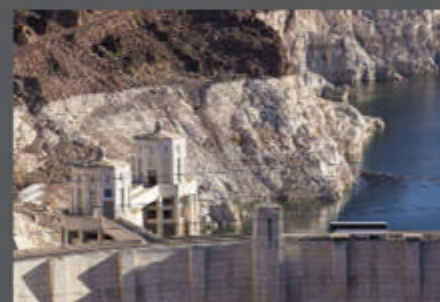
America's reservoir dries

IF CALIFORNIA'S prolonged dry spell is eventually recognised as a megadrought, no one can say we weren't warned. Lake Mead, the largest reservoir in the US, has hit its lowest level ever. Feeding California, Nevada and Arizona, it can hold a mind-boggling 35 cubic kilometres of water. But it has been many years since it was at capacity, and the situation is only getting worse.

"We're only at 38 per cent full. Lake Mead hasn't been this low since we were filling it in the 1930s," said a spokeswoman for the US Bureau of Reclamation in Las Vegas.

If it gets much lower - and with summer approaching and a dwindling snowpack available to replenish it, that looks likely - official rationing will begin for Arizona and Nevada. The hydroelectric output of the Hoover dam (below), to which the lake owes its existence, could also suffer. Water restrictions are already in place in California, but some hydrologists say rationing there must start soon to avert disaster.

A drought must last at least two decades to be considered a megadrought. California's dry spell isn't quite there yet - it has endured for 15 years - but has already been classed as the worst drought of the last 1200 years. Rowan Hooper



Photographer

Rex_Shutterstock

Spreading resilience

After the disaster in Nepal, what hope of better earthquake preparedness in Himalayan nations, wonders **Alex Densmore**

EARTHQUAKES cannot be predicted, beyond saying that where they have happened in the past, they will, someday, happen again. After April's earthquake in Nepal – and scenes reminiscent of similar events across the Alpine-Himalayan mountain belt in the past decade – it is natural to ask how we might improve resilience.

Amid damage in the capital, Kathmandu, it is tempting to pin all of the blame on buildings: if only the region had better buildings and strict construction codes could be enforced, such scenes would not recur so frequently. This is true, but only to an extent. Nearly all countries across the region, including Nepal, do have codes that require earthquake-resistant construction – but in all of them, countless buildings fall short. There is no excuse for new structures not meeting or



exceeding standards, especially the schools, hospitals and government offices that are very important after a disaster. Donor agencies that often fund construction are aware of this.

Retrofitting programmes for older buildings, although patchy, have made some headway in the Kathmandu valley and elsewhere. But it is impractical to retrofit the millions of unreinforced brick and stone houses across the region.

And better building codes would not have saved earthquake-hit villagers buried by landslides in Pakistan in 2005. Better concrete could not have stopped the burial of scarce farmland under sand and gravel in the valleys of Sichuan in China's 2008 tremor. Better buildings cannot cure the cholera caused by disrupted water supplies.

We need to recognise that resilience is not just about

Testing times

A big petition questions animal experiments in Europe. Some are vital, says **Catherina Becker**

IN MY lab we study the incredible ability of zebrafish to self-repair spinal cord injuries. It's an enormously complex process. To regain function, connections from the brain to the spinal cord must regrow, different types of immune cells have to clear the injury site, and stem cells in the spinal cord need to generate new

nerve cells, which then connect to the muscles. By studying all this, we hope to learn what signals are needed for repair in humans.

Even though potential advances are great, the decision to use animals is something that no researcher takes lightly. Animal experiments in Europe are highly regulated – by a directive passed

in 2010 after wide consultation. Animals can only be used if there is no viable alternative and high standards of welfare are applied.

However, there are those who say this is not enough: the group Stop Vivisection wants the directive abolished and has submitted over a million signatures to the European Commission. Under the European Citizens' Initiative, a million signatures triggers a meeting of the EC to consider the petition.

"No one is saying allow all animal experiments, but some are still needed for fundamental research"

It's due on 11 May.

Biomedical researchers, supported by European and UK regulations, strive for reduction, replacement and refinement of animal use where possible, for example by using cell cultures and computer models instead. My university has a great track record in developing such strategies.

But animals are vital for many areas of research linked to human health. The study of regeneration in complex organs like the liver or spinal cord is one such area. It cannot currently be simulated.

Work on animals by European research institutions has led to advances, such as Jasper the

better buildings. It begins with individuals – be they in families, villages, districts or nations. It is spread to them through dedicated and inspirational groups raising awareness of earthquakes, teaching practical household lessons in reducing risk, and helping survivors to recover and rebuild. These include the National Society for Earthquake Technology in Nepal, the Bihar State Disaster Management Authority in India, the Geological Survey of Iran, and the Hong Kong Polytechnic and Sichuan universities in China. Resilience is also spread by hard lessons on landslides learned from earthquakes in Pakistan and China, which are now guiding decisions in Nepal.

People struggle to prioritise earthquake risks when set against pressing daily concerns such as poverty, hunger, air and water pollution, and urban congestion. Such priorities are understandable.

But experiences across different disasters and cultures form a growing and powerful resource that shows us how to live with, and live through, the earthquakes that we face. ■

Alex Densmore is a professor of geography at Durham University, UK. This article reflects his work with Earthquakes Without Frontiers

sausage dog and Polish man Darek Fidyka walking again after experimental treatment for spinal injuries. Stopping all animal use, before alternatives are found, would block such progress here and push research abroad.

No one is saying allow all animal experiments, but some are needed for fundamental research in preclinical studies that will ultimately translate into medical practice. Tearing up the directive to halt all animal use would be a step backwards. ■

Catherina Becker is director of the Centre for Neuroregeneration at the University of Edinburgh, UK

ONE MINUTE INTERVIEW

Habeas corpus for chimps

Chimps housed in research facilities deserve the same legal protections as human detainees, says lawyer **Steven Wise**



PROFILE

Steven Wise heads the Nonhuman Rights Project and has practised animal protection law for 35 years. He has taught animal rights law at universities including Harvard and is the author of books such as *Rattling The Cage* (Basic Books)

You've been granted a groundbreaking court order that means Stony Brook University in New York has to legally justify keeping two research chimpanzees. What happened?

We filed a petition under a habeas corpus statute, which is usually used to bring a prisoner or detainee before a court to determine if detention is lawful. For the first time, a judge has ordered someone detaining chimpanzees to come to court and argue that it is legal. The arguments will hinge upon whether two chimpanzees, Hercules and Leo, are entitled to legal personhood rather than being viewed as legal things.

Why these two chimpanzees?

Hercules and Leo are young males being used by the anatomy department to study the evolution of locomotion. Both, we believe, are being held indoors. That goes against the US National Institutes of Health's guidelines that the few chimpanzees that remain in research are to be kept in groups of not fewer than seven, a mix of males and females, in a natural-like environment.

Why not fight that using animal welfare law?

Animal welfare statutes don't work in the US. A legal person, on the other hand, is highly visible to the courts. The difference between being a legal person and being a legal thing is profound. A legal thing is more or less invisible to judges; they don't have inherent rights. They are only important to the degree that they are important to a legal person. They are essentially slaves.

Would such a ruling grant human rights to chimpanzees?

No. We are looking for chimpanzee rights for chimpanzees, looking to understand what the most fundamental interests of chimpanzees are and giving them rights to protect those interests.

Why do chimps deserve legal personhood?

They have been studied for well over half a century, in the wild and in captivity. The findings only go one way – chimpanzees are extraordinarily complex cognitive beings with minds that are startlingly close to ours. More importantly for our argument, they are autonomous and self-determining, not just bound by instinct. It is also clear that they are autonomous in a way that is very familiar to us as human beings. Courts have shown the utmost respect for autonomy. For example, if someone rejects medical treatment, the court respects their right to autonomy, their right to die. Autonomy is of supreme value.

Surely there are no rights without responsibilities?

We have no problems giving rights without responsibilities to millions of humans, for example if they are insane or just very young.

Do you sense victory for your arguments at the hearing on 27 May?

This is the first time we have got this far. We are in new territory. So it's hard to say what will happen. We will eventually prevail – it's just a matter of time – but I don't know how long it will take.

Interview by Jon White

The unique pain of being human

We seem to experience pain differently to other animals. Why, wonders neuroscientist **Barbara Finlay**

FOR years I worked in Brazil on the evolution of vision in primates and was often stationed near monkeys who had undergone caesarean sections. Their recovery was impressive – in stark contrast with my own after two C-sections. Within hours, the monkeys would be sitting, climbing and annoying each other.

Looking at these unbothered monkeys, I began to think that some causes of the sensation of pain in humans might be fundamentally different to those in other animals.

The basic function of pain is the same for all vertebrates: it alerts an animal to potential damage and reduces activity after trauma. It is often argued that pain must be different in humans because of our ability to anticipate it or imagine its effects on us. But independent of whether cognition and culture can modify pain, I am suggesting a more basic difference in humans compared with animals: that some varieties, such as labour pain, appear only in humans, and others such as post-trauma pain are magnified.

These forms of pain appear in tandem with the ability to recruit help, to elicit an altruistic response in others. By “help” I mean the simple protection and provisioning that parents supply to children, not medical intervention – although our medical interventions probably first grew from this basis.

This view arises from work carried out nearly 50 years ago by pain researcher Patrick Wall. He was the first person to suggest a functional view of pain – that it should be understood as a mixture of sensation and the motivation to make it stop, not sensation alone. His starting point was the now well-researched placebo effect. His account

explained how rituals or procedures offered by a doctor or shaman, regardless of the efficacy or even existence of an actual treatment, could reduce pain.

But even with this early advocate for a functional view of it, studies of pain have mainly concentrated on receptors and specific clinical manifestations, while neglecting its purpose. Pain is a motivational signal to get an animal to do something – escape from a source of damage, protect a wound or devote energy to recovery. Wall argued that one of its roles in humans is as a motivation to seek help from some trusted source. When that goal is satisfied, pain is relieved.

I want to extend this view. I think that, over evolutionary time, several stimuli and situations that are not painful in other animals have come to be experienced as painful for humans. This is because our obvious distress elicits help from others and hence offers a survival advantage. This is distinct from the numerous demonstrations that context and culture can alter our sensation of pain. I argue that the primary circuitry of pain and malaise has been changed in human evolution in cases where getting help from others would be useful.

The pain of altruism

There is much indirect evidence in support of this “pain of altruism”. Take, for instance, the fact that certain types of pain are not associated with any physiological damage, and studies that show the presence of others can affect reported sensations of pain. Labour pain is another good example.

Across all human cultures, there are nearly always helpers, from relatives to medical

PROFILE

Barbara Finlay is a neuroscientist at Cornell University in Ithaca, New York, who researches the evolution and development of the vertebrate nervous system

Cry for help: it's just what nature wants you to do

professionals, who attend births. Giving birth is risky and help at any level improves survival. The cliché scenario of a mother from some exotic tribe going off to give birth alone is not unheard of, but is exceedingly rare. By contrast, among our primate relatives, solitary birth is the norm.

Human childbirth appears to be uniquely painful among members of the animal kingdom. Typically, scientists have accounted for this in terms of the size mismatch between the infant's head and the mother's pelvis, and not in terms of differences in social structure.

Human birth is dangerous, but we are not the only primates at risk – the smallest-bodied, large-brained monkeys, like marmosets, have similar head to pelvis disproportionality and birth-related mortality. Yet compared with





humans, primates appear to give birth with little pain. Ungulates such as horses and cattle produce large, long-limbed offspring with a substantial chance of complications, but with little evidence of distress. Any such evidence, in fact, could prove fatal by alerting predators. So why is childbirth so painful for women?

The source of labour pain is the contraction of the uterus and dilation of the cervix, but these are not damaging or pathological in themselves. Rather they predict a risky and potentially lethal event: the actual birth, to occur hours later. I suggest that protracted labour pains make us show distress and recruit help from others well in advance of the birth – a strategy that offers a survival advantage, as the offspring of those who seek help are more likely to survive.

OTHER UNEXPLAINED AGONY

Pain exists to get an animal to change its behaviour. This functional account of pain may explain some ongoing mysteries, such as the cause of the muscle soreness that follows a day of intense exercise, which has eluded physiological explanation. The popular idea that it is due to the build-up of lactic acid has been discounted, as have other proposed theories. Bodybuilders have found that the optimal way to build muscle is to take a rest day after a strenuous workout. Perhaps nature has converged on the same idea, and muscle soreness is simply a signal to rest, to enable optimal muscle building.

But if the pain of labour is not linked to tissue damage and is primarily a call to enlist help, why does it have to be so excruciating?

Helping someone in pain comes at a cost to the helper, and societies can't afford to tolerate "cheating" in the form of excessive malingering or fake pain. I think that the pain of altruism may be connected to the concept of honest signalling in behavioural biology, whereby producing a signal has to be sufficiently costly to deter cheaters and freeloaders. Pain could be the obligatory cost of an honest signal, in the same way that a

"The availability of help from others might be the root cause of some pain"

peacock's tail or stag's antlers are hard-to-fake signs of their owner's underlying fitness. However, since pain has no concrete physical manifestation that others can verify, cheating is difficult to eliminate – there is probably not one person reading this article who has never exaggerated pain or illness for their own benefit.

If feeling pain to recruit the help of others is an evolutionarily assembled neural construct, this could be triggered in error. Perhaps this is what happens in the case of mysterious but distressing illnesses for which a direct physical cause cannot be found.

The pain of altruism also explains why malaise after trauma and infection are long and exaggerated for humans compared with laboratory mice. Mice, like most non-human animals, cannot provide the high level of social support needed to nurse an individual with an illness or a broken leg. Such injured animals must confine their energetically expensive immune response to the minimum time needed to survive without help.

It is also possible that this pain of altruism has been extended to domesticated livestock and pets, as they too can enlist human help. In contrast, most adult animals in the wild try to avoid showing disability or distress, which might attract rivals or predators.

Periods of extended illness might only be feasible in species where individuals protect and provide for others for such lengths of time. If help from others is the root cause of some types of pain, then this needs to be factored into our understanding of pain and disease. An evolutionary calculation that we cannot be aware of, rather than a specific physical cause, could be the source of much real agony. ■

MIKAEL ANDERSSON/PLANIPICTURE

A I N G C T O N O G N O C T A N O I T O N A G C O I N C O N T A G I O N

Are we really a few mutations away from the end of the world as we know it?
Emma Young investigates

OCTOBER 2014. The World Health Organization warns that there could soon be more than 10,000 new Ebola cases in west Africa every week. “We either stop Ebola now – or we face an entirely unprecedented situation for which we do not have a plan,” declares the head of the UN response team. As pictures of the dead lying in the streets race round the world, many fear a runaway pandemic of Hollywood proportions.

In the US, these fears reach fever pitch after a man who had just returned from Liberia dies of Ebola. A teacher who stayed in a hotel 10 miles away from the hospital where the man was treated is told to stay away from school just because she’d been in the same town. A busload of passengers is quarantined when a woman vomits after getting off.

Six months on, the picture is very different. Ebola has faded from the headlines. With belated help from around the world, the outbreak has been contained, if not yet eradicated. In total, just over 10,000 people have died – an awful toll but hardly comparable to the Spanish flu of 1918, which killed around 50 million, or the Black Death, which wiped out half the population of Europe in the 14th century.

The fact that Ebola sparked such panic is perhaps more a reflection of our appetite for books and movies featuring catastrophic

plagues than reality. But are those scenarios pure fiction? Are we now advanced enough to beat the worst that nature can throw at us? Or have we just been lucky? Are there viruses out there that are just a few mutations away from becoming unstoppable killers that really could wipe out half the human race?

Killing potential

Four factors determine the severity of any disease outbreak, says epidemiologist Christophe Fraser of Imperial College London: how deadly it is; how easily it spreads from person to person; if and how long a person is infectious before symptoms appear; and whether it can be prevented by vaccines, treatments or both. Diseases can wreak havoc even if they have only some of these traits, but it is the ones that score highly on most or all of them that we really need to worry about.

Looked at this way, Ebola is less fearsome than it first appears. True, it is deadly, killing more than half the people it infects, and no vaccine is yet available. But it doesn’t score highly on the other factors. It isn’t easily transmitted, as it only spreads via direct contact with body fluids. And people are not infectious until they start showing symptoms, so they can be isolated or quarantined before passing on the disease to others.

Ebola was therefore never likely to rampage out of control in rich countries. It managed to infect so many people this time round only because of poor healthcare, and because people did not know how to stop it spreading, says Derek Smith of the University of Cambridge, who studies emerging infectious diseases. Once well-established protocols were in place, it was quickly contained even in some of the poorest countries in the world.

If the Ebola virus mutates to become airborne, it would become more of a threat – but most virologists think such a change is unlikely. The virus would have to undergo major changes, such as being able to bind to and infect the cells lining the upper airway.

And even when viruses can spread via the air, they do not necessarily run riot. In 2002, for instance, people in China began to die of what was called Severe Acute Respiratory Syndrome. SARS was better at spreading than Ebola, and airborne transmission was implicated in at least one cluster of cases. Within months it had reached dozens of countries, infecting around 8000 people and killing about a fifth of them.

Crucially, though, it scored low on factor three: symptoms appeared before people became infectious, so they could be quarantined before they began spreading the virus. This, along with the rapid discovery of the virus and how it spreads, stopped the ➤



outbreak within a year. “Most virologists think modern science and public health measures stopped a global and very serious SARS pandemic,” says Smith.

There is one deadly virus that scores very highly on factor three: people with HIV are infectious for years before symptoms appear. This has enabled the virus to spread around the world and kill around 36 million people, even though it is very poor at spreading from person to person.

H1N1 swine flu, by contrast, spreads with ease. It is contagious for about a day before symptoms appear, and when it first emerged in 2009 no vaccines were available. Over half the world’s population was probably infected

It’s a close relative of SARS that is keeping many virologists awake at night at the moment. MERS, or Middle East Respiratory Syndrome, emerged in Saudi Arabia in 2012. It keeps jumping into people from some animal host, possibly camels. It has infected around 1000 people and killed 400. Fortunately, it rarely spreads from person to person, but the more people it infects, the more opportunities it will have to evolve this ability.

Even if MERS never starts spreading from person to person, another animal virus is certain to at some point. If we don’t stamp on these emerging diseases quickly, as we did with SARS, a global pandemic could result.

The good news, though, is that it is unlikely that an animal virus jumping into humans could instantly acquire the four traits of a perfect killer. In particular, they are usually poor at spreading from

person to person. The viruses that spread most readily in people, like the cold-causing rhinovirus, have evolved this ability over countless generations of plaguing our ancestors. And as viruses get better at spreading, they tend to become less deadly – although this may not always be true.

But there is one virus that might be able to acquire all four traits almost instantaneously: flu. New strains of human flu already tick almost all the boxes: they spread readily from person to person, are infectious for at least a day before symptoms appear, and it takes six months to a year to make a vaccine. The one trait they lack is deadliness. By contrast, some animal strains of flu, such as the H5N1 bird flu

that emerged in 1996, are extremely deadly when they manage to infect people but very rarely pass from one person to another.

Influenza viruses not only have a high mutation rate, they also have a nifty trick up their sleeve: they can “reassort”. The flu genome consists of eight pieces of RNA. When two different flu strains infect the same cell, their progeny can have a mixture of RNAs from both strains – and thus a mixture of their characteristics. “At least three out of four pandemics of the last century emerged upon reassortment of flu viruses in humans or pigs,” says Fouchier.

Colossal threat

So the crucial question is whether mutation, reassortment or both could create a form of flu that combines the deadliness of some bird flu strains with the infectiousness of the strains that circulate in people. Such a virus would be a colossal threat, capable of killing on a catastrophic scale. This is what Fouchier and others have been trying to find out.

In 2012, after tinkering with the H5N1 virus and seeing if they could infect ferrets, he and his colleagues announced that with just a few mutations in two genes, the H5N1 bird flu strain might be able to spread readily in humans. First, the virus would have to become capable of binding to receptors on epithelial cells in our upper respiratory tract. In most viruses, such as Ebola, this requires major changes, but with bird flu only minor tweaks will do it. Second, it would have to be able to replicate effectively at a lower temperature, because the human upper respiratory tract is cooler than the gut of the bird. Altogether just five mutations might do the trick – and there

“Could a flu virus emerge that combines the deadliness of bird flu with the infectiousness of human strains?”

within the first year, says Smith. Thankfully, the strain was not much more lethal than normal flu, although it was more likely to hit younger people hard.

So none of the diseases that have emerged recently ticks all the boxes in Fraser’s four-point profile of the perfect killer (see graphic). Have we just been lucky? Could such a pathogen emerge in the future?

Public health advances have undoubtedly helped prevent emerging diseases like SARS and Ebola killing many millions. Yet in other ways, we are more vulnerable than ever before. There are now 7 billion of us on Earth – an awful lot of potential hosts for a pathogen to exploit. And thanks to air travel, diseases can spread around the world faster than ever.

There is certainly no shortage of viruses waiting in the wings. Diseases like Ebola are caused by viruses that live in animals jumping into humans: bats are thought to be Ebola’s natural host. And it’s estimated that mammals alone play host to hundreds of thousands of unknown viruses.

We already know that a few are capable of killing people given half a chance. The Nipah virus, for instance, was first identified in Malaysia in 1998 after killing 105 people. Should we be concerned about these kinds of viruses? Definitely, says Ron Fouchier of the Erasmus Medical Centre in Rotterdam, the Netherlands, who helped identify SARS. “Perhaps they could acquire the ability to sustain transmission between people. We don’t know.”

Plague potential

Four main factors determine how severe a disease outbreak will be. We are yet to face a virus that ticks all the boxes

	Ebola	SARS	HIV	H1N1 swine flu (2009)	H5N1 bird flu	MERS
Deadliness <i>Kills a large proportion of infected people</i>	☒	☒	☒	☐	☒	☒
Spreads readily <i>Infected people rapidly infect others</i>	☐	☐	☐	☒	☐	☐
Hard to contain <i>People become infectious before showing any symptoms</i>	☐	☐	☒	☒	☒	☐
No vaccine at first <i>It takes months at least to mass produce a new vaccine</i>	☒	☒	☒	☒	☒	☒



Deadly H5N1 bird flu continues to circulate in wild and domestic birds

that a virus with similar properties won't emerge in future, he says. "And there is little evidence that we could effectively control the global spread of such a virus."

The number of deaths is also only part of the story. The Ebola outbreak may only have killed 10,000, but the impact on the most-affected countries has been devastating. Whole countries have been shut down for days at a time, with borders closed, regions quarantined, schools shut for months and flights cancelled. Nearly half of workers were unable to earn a living even as food prices rose. Developed countries may be even more vulnerable to this kind of disruption, as their societies are so much more complex and interdependent.

For those who fear a sci-fi-style apocalyptic plague, though, the idea that the biggest threat is a rerun of the 1918 flu pandemic may be reassuring. But no one can be sure what's coming next. "Viruses are unpredictable," says Fouchier. "There will always be new ones that come when they're least expected."

And while it doesn't seem likely, the possibility that we'll find ourselves facing a particularly nasty one cannot be ruled out. "It is feasible to imagine worse epidemics than we have experienced in the last century," says Fraser. "I would advocate preparing for such eventualities."

It is not just wild viruses we need to worry about. Fouchier's tinkering with H5N1 triggered a storm of controversy: might the engineered viruses start a pandemic if there was a slip-up in the lab? Was the published work tantamount to a recipe for creating a terrible bioweapon? There are good grounds for concern. The 1977 flu pandemic was probably caused by the escape of an old human flu strain from a lab, for instance.

The furor over Fouchier's work has led to an effective ban on this kind of flu research for now, but flu is not the only threat. In 2001, *New Scientist* revealed that biologists had accidentally created an extremely deadly version of a rabbit virus. In 2003, "biodefence" researchers in the US deliberately altered a mouse virus in this way. Could a deadly virus capable of spreading in people be created accidentally or deliberately, and somehow escape the lab? Let's hope we never find out. ■

Emma Young is a freelance writer based in Sheffield, UK

are other strains of H5N1 out there that already have two of these mutations, which the nasty strain could acquire by reassortment.

Could this really happen? "We found that it's certainly within the realms of possibility," says Smith, whose team has investigated how easy it might be for the virus to mutate in this way.

This sounds extremely alarming, but there are two big "buts". Firstly, while 60 per cent of people hospitalised with H5N1 bird flu have died, Fouchier thinks that many mild infections have gone undetected, meaning it is not as deadly as it appears.

Secondly, while it might not take many mutations for H5N1 to become more infectious, the same mutations could well

travel as deeply into the bodies of other people before reaching cells they can infect.

So when bird flu viruses mutate to target the upper respiratory tract, they may become less deadly. But even if this process reduced the lethality of an airborne virus by 10 or even 100 times, it would still be thoroughly nasty, Smith says, killing perhaps 1 in 200 people – on the scale of the 1918 Spanish flu pandemic.

And this is as much as we know for now. While it seldom makes headlines any more, the threat from bird flu certainly hasn't gone away. In fact, it has grown worse. Not only is H5N1 still circulating in wild and domestic birds, but a nasty new H7N9 bird flu emerged in 2013. "Based on what we know, it would require only

a little bit of tweaking to acquire airborne transmissibility," says Fouchier.

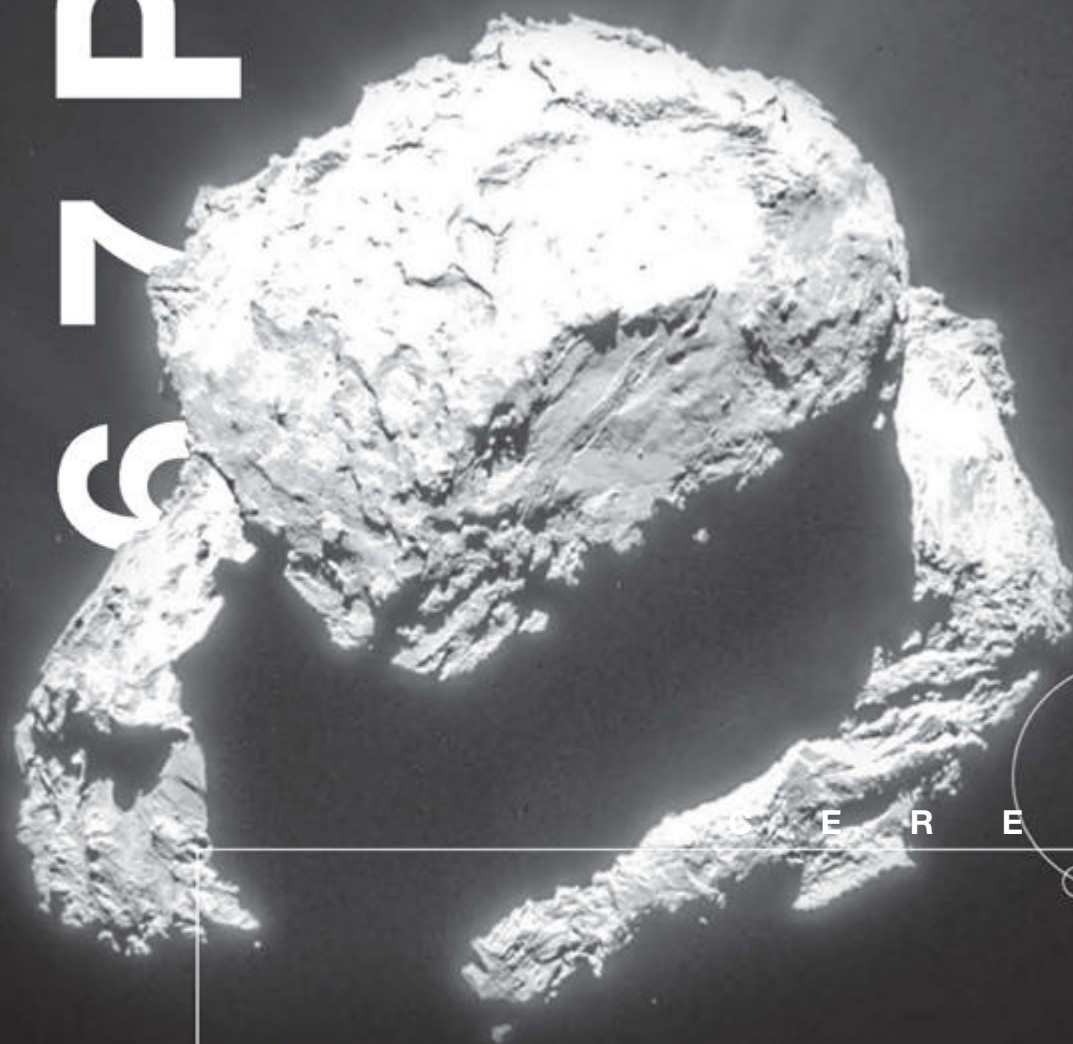
If it did, could we stop a 1918-style virus rampaging around the world? The vaccine for

2009 H1N1 swine flu arrived only after the first wave of infections around the globe, but Fouchier thinks we might do better next time. "If we recognise the threat very, very early, there's a good chance we'd be able to protect some of the at-risk groups in time," he says. "We certainly should be able to protect everybody for the second wave."

So Fouchier and Smith think the death toll from pandemic flu will never be as high as 1918. Fraser thinks otherwise: we can't assume

"It is feasible to imagine worse epidemics than we have faced in the last century. We should prepare for such eventualities"

make the virus less deadly, Smith says. The reason is that deadlier strains tend to target cells deep in the lung, damaging the alveoli and causing people to essentially drown in their own bodily fluid. By contrast, seasonal flu viruses generally infect only the upper respiratory tract. This makes them both less deadly – because they don't damage the lungs – and more infectious, because viruses shed from the upper airways are thought to exit the body more easily and don't have to



What Rosetta did

Two days after the Rosetta mission's Philae lander touched down on comet 67P last November, it ran out of battery. As we wait to see if it will revive, an intriguing find is already raising questions about what comets are made of – and with it Earth's own history (opposite). Meanwhile back on the ground, technologies that made Rosetta possible are finding some unexpected uses (page 38)

The wrong water

Where did Earth get its life-giving liquid? Slurps of cometary wet stuff leave us facing a mystery, says **Stuart Clark**

COMET might be the proper term, but “dirty snowball” would be more descriptive. Travelling in large, elliptical orbits that periodically bring them from the solar system’s outer reaches to its inner regions, these mountain-sized lumps of ice and rock boil off when bathed in the sun’s rays, giving rise to their trademark tails.

The wonder – and fear – these cosmic wanderers have inspired over centuries is reason enough to seek a closer encounter. But comets are also windows on the solar system’s ancient past, being bits left over from the formation of the planets billions of years ago. So planetary scientists were expecting a treasure trove of information when, late last year, the Rosetta mission beamed back its first data from 510 million kilometres away, as it arrived at the comet 67P Churyumov-Gerasimenko.

They haven’t been disappointed. The mission has already revealed that the comet, unexpectedly, has almost no magnetic field, while some of its surface features seem to have been formed by wind. But most intriguing is what has emerged about the water 67P contains – and what that might mean for how Earth itself became wet.

Comets have long been crucial for explaining Earth’s water. In our planet’s early days, water would just have boiled away from its hot surface. To get around this problem, a well-established theory is that our planet received an express delivery of life’s vital solvent later on, when it was bombarded by icy bodies like comets. Although atmospheric weathering and tectonic activity have erased obvious evidence from Earth, the moon’s cratered face tells us that such bombardments did happen during the solar system’s convulsive early aeons. This cometary ice also contained carbon-rich molecules, supplying Earth with a starter pack for life, freeze-dried for freshness.

But that’s not the story Rosetta tells. “Even before we did any analysis we could see that the cometary water was completely different from the Earth water,” says Kathrin Altwegg of the University of Bern in Switzerland. She is in charge of Rosetta’s ROSINA instrument, which scrutinised the water it encountered when passing through 67P’s tail.

Ordinary water is made of two hydrogen atoms bound to an oxygen atom. But just occasionally, one or both of those hydrogens is replaced by deuterium, a stable isotope of hydrogen with an extra neutron in its nucleus. On Earth, there are roughly 160 molecules of this “heavy water” for every million ordinary molecules, a number known as the D/H ratio.

The D/H ratio of 67P was triple that of Earth – confirming a discrepancy that has been in the air a while. In 1986, Altwegg was a young researcher on the European Space Agency’s Giotto mission when it rendezvoused with and photographed Halley’s comet. Indirect spectroscopic measurements suggested Halley’s D/H ratio was twice Earth’s. Similar studies of around a dozen comets since have indicated something similar: only one, named Hartley ►

ROSETTA'S TIMELINE

MARCH 2004

Mission launched from French Guiana

MARCH 2005

First Earth flyby provides a gravitational slingshot towards comet 67P

FEBRUARY 2007

Low altitude flyby of Mars

NOVEMBER 2007

Second Earth flyby. Rosetta is mistakenly identified as a near-Earth asteroid and given the name 2007 VN84

SEPTEMBER 2008

Rosetta passes through the main asteroid belt

NOVEMBER 2009

Rosetta passes within 2500 km of Earth on its third and closest flyby

JUNE 2011

Rosetta starts deep-space “hibernation” with most electronics switched off

JANUARY 2014

Rosetta woken up from deep-space slumber and resumes communication with Earth

AUGUST 2014

Rosetta arrives at comet 67P and begins to map viable landing locations from 100km away

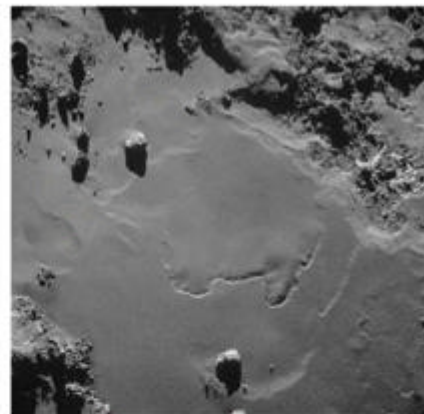
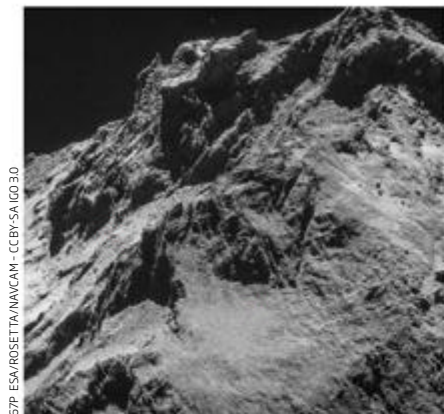
NOVEMBER 2014

The lander Philae touches down bumpily on the comet’s surface. Harpoons to tether the craft to the surface fail to fire

MARCH 2015

Attempts to contact Philae to see whether its solar batteries have recharged as the comet nears the sun

"It seems comets can't have been the source of Earth's water. So what was?"



ESA/ROSETTA/NAVCAM - CCBY-SA 4.0 30

2, contains water with a similar D/H ratio to Earth's oceans.

That would seem to indicate comets weren't the source of Earth's water. So what was?

Asteroids are one alternative – one that had long been ruled out. The closest, brightest of these bodies, which orbit in a belt between Mars and Jupiter, are bone dry. And while some meteorites found on Earth, which are thought to have been flung from more distant members of the asteroid belt, do contain water with the right D/H ratio, there isn't nearly enough to supply Earth's oceans.

ASTEROID AHOY!

The arrival of NASA's Dawn mission at Ceres has already excited interest in this dwarf planet and largest of the asteroids (28 March, p 8).

The way the Dawn spacecraft bobs around while orbiting Ceres in the coming months will tell us about the dwarf planet's internal structure, helping to determine its density and exactly what fraction of ice it contains. Meanwhile, three instruments will investigate the crucial question of its water content directly (see main story). Its camera will check for surface ice deposits, or other features shaped by past ice. Its spectrometer should see telltale frequencies of infrared light given off by water locked inside surface minerals, and also reveal organic material if it is there. Finally, its neutron detector will look for the effect of water ice on and just below the surface on the emission of neutrons from the surrounding rocks – a technique

At least that was the view when Laurence O'Rourke, Rosetta's science operations coordinator, started using another of ESA's missions, the infrared space observatory Herschel, to look for water on asteroids. Specifically, he was targeting the largest of the asteroids, Ceres, some 1000 kilometres in diameter and now classed as a dwarf planet.

Ceres orbits in the middle of the asteroid belt, following an elliptical path that varies in distance from the sun from about 2.6 to 3 astronomical units (1 AU is the distance of Earth from the sun). This crucial region

already successfully used on the moon and Mars.

NASA is not the only space agency with its sights set on the asteroids. Last year, the Japanese space agency JAXA launched Hayabusa 2, which is due to arrive at the unassumingly named 1999 JU3 in 2018. In addition to mapping and spectroscopic observations, it will descend to the surface and collect samples, returning them to Earth in 2020 if all goes well.

"C-type" asteroids such as 1999 JU3 are thought to be the parent bodies of a rare type of meteorite, the carbonaceous chondrites. These are distinguished by their dark colour and an abundance of organic molecules, and those found on Earth display all the hallmarks of having been formed in the presence of water. In short, they – and perhaps their parent bodies – seem to have all the ingredients needed to fill the oceans and spark life on Earth.

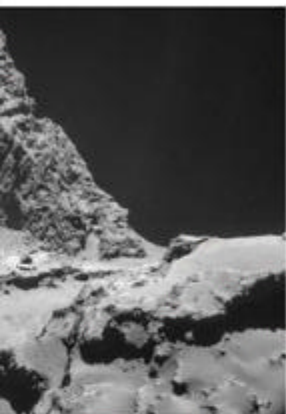
straddles the solar system's snow line, the boundary beyond which the sun's rays are so weak that any water condenses to ice crystals.

"Ceres is in this really special place, where ice was starting to become a major planet-building material. As you went further from the sun, you got more and more ice crystallising," says Britney Schmidt, a planetary scientist at the Georgia Institute of Technology in Atlanta. With a density around 2000 kilograms per cubic metre that is neatly in between that of ice and rock, Ceres, and its more distant asteroid siblings generally, could plausibly be half rock and half ice. Such asteroids could have supplied significant amounts of water to the early Earth.

Sadly, O'Rourke's first measurements in November 2011 revealed a disappointingly desiccated body. It was a different story when he looked again in October 2012. "We got a very strong detection of water," he says – the first confirmed detection of water in the asteroid belt.

What had changed was Ceres's position. In 11 months, its orbit had taken it from 3 AU to 2.7 AU from the sun, enough to come within the snowline and turn some of its ice to vapour. About 6 kilograms of water was being released every second, surrounding the asteroid in a tenuous atmosphere rather like a comet's. In fact if comets are dirty snowballs, asteroids such as Ceres look increasingly like they might be snowy dirt balls.

NASA's Dawn mission, which was captured by Ceres's gravity on 6 March to begin a 16-month study of the dwarf planet, is one probe that could provide more clues to its composition (see "Asteroid ahoy!", left). But regardless of what Dawn finds, it's unlikely to be as simple a picture as one in which bombardment by material from asteroids, rather than comets, brings water and organic



Rosetta has delivered the most detailed picture of a cometary surface yet

Earth's oceans. "It's like paint, you mix red and yellow and you get orange. So, if you have a component that's three times 'heavier' than Earth water and a component that's three times 'lighter' and you mixed them 50:50, you'd get Earth water," says Wright.

The answer to where that lighter component might come from might lie in our still-emerging understanding of the solar system's "water cycle": a sequence of events that began when the sun and the planets were nothing more than a frigid mixture of gases drifting through space. In these interstellar clouds, atoms occasionally stick together and form molecules. By a quirk of chemistry, the isotopic composition of any water formed depends on temperature: the colder it is, the more deuterium it ends up containing. Interstellar clouds are typically at a frigid -220°C to -260°C , which will yield D/H ratios at least three times those on Earth.

But under the warming influence of the nascent sun, some water molecules would have been broken up and reformed, lowering the D/H ratio as they did so. So in all probability bodies formed across the solar system with a huge range of D/H ratios, as indeed the observations of comets so far suggest – and Earth got bombarded with a selection of them all. That, combined with some moisture baked out of our planet's interior by a process known as outgassing, might have supplied the right sort of water. The fit is still not perfect: bodies with a Ceres-like distance are likely to have lower D/H ratios, but models show that making asteroids with exactly the right low D/H ratio takes too long.

Whatever the full story, the tale of the wrong water does shed new light on comet 67P itself. Its extraordinarily high D/H ratio suggests we have, more by luck than judgement, stumbled on a body that has more claim than most to represent the pristine material that made the solar system – its water is, in Altwegg's words, "more or less purely interstellar".

More detail might have to wait for the hoped-for reawakening of Rosetta's lander, currently languishing in a crevasse (see "Come in, comet", left). But it's all the more reason to regard these bodies with awe and wonder. "The beauty about studying a comet is that the stuff that has been there for 4.5 billion years," says Wright. "You warm it up and you can basically say that's the stuff that was on the surface of the Earth. I think that is fantastic." ■

Stuart Clark is a consultant for *New Scientist*. His latest book is the forthcoming *The Unknown Universe* (Head of Zeus)

molecules to Earth. "That can't be the whole story," says Ian Wright of the Open University in the UK.

The reason is written once again in the moon's cratered face. Most models of the solar system's evolution involve the giant planets – Jupiter, Saturn, Uranus and Neptune – migrating closer or farther away from the sun before settling into their final orbits. These movements would have upset comets' orbits, throwing some into the inner solar system.

So there must be at least some cometary water with its heavy make-up mixed into

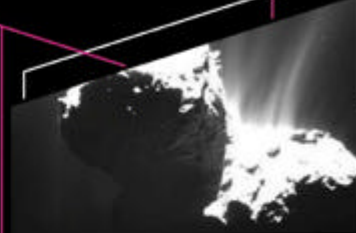
COME IN, COMET

The hop, skip and jump of Rosetta's Philae lander last November curtailed some of the mission's ambition. Philae did sample gases coming off comet 67P during its acrobatic surface crossing, but its resting place in a dark crevasse meant it ran out of power before it could drill out a solid chunk.

Getting such a sample would be crucial to determining 67P's exact make-up. The hope is that Philae will revive as 67P gets closer to the sun, strengthening the sliver of sunlight that is reaching its solar panels. "The spacecraft engineers do not seem pessimistic about it, so I think there is a good chance Philae will wake up," says Ian Wright of the UK's Open University.

Rosetta is keeping a watchful eye on its lander, and according to Stephan Ulamec, the lander's manager, a wake-up call is most likely to happen this month or next. "We might only be a short time from being able to do that rather than having to wait 20 years for a follow-on mission," says Wright.

67P



67P/Churyumov-Gerasimenko

Discovered: **1969**

Classification: **Comet**

Home: **Solar system wanderer, between 190 and 850 million km from the sun**

Orbits: **Every 6.5 years**

Spins: **Every 12.5 hours**

Appearance: **Misshapen chunky duck**

Composition: **Dirty ice ball, ice and dust tail**

Size: **Roughly 5 km by 3 km**

First visited: **ESA Rosetta mission, 2014**

CERES



Ceres

Discovered: **1801**

Classification: **Asteroid; dwarf planet (since 2006)**

Home: **Asteroid belt between 380 and 450 million km from the sun**

Orbits: **Every 4.6 years**

Spins: **Every 9 hours**

Appearance: **Round and pockmarked, mysterious bright spots**

Composition: **Icy dirt ball, possible liquid water inside**

Size: **950 km in diameter**

First visited: **NASA Dawn mission, 2015**

It came from outer space

Rosetta's technology is already finding some unexpected uses on Earth, says **Andy Ridgway**

BEDBUGS have had it their own way for a long time, sucking our blood while we sleep and evading detection by dint of their nocturnal lifestyle and millimetre-scale bodies. Our first visit to a comet could mark the point where the tables began to turn. A portable bedbug detector that sniffs out the chemical signals they send to one another is just one of many unusual spin-offs from the Rosetta mission, which arrived at comet 67P late last year (see page 35).

It's not surprising that many space technologies soon make their way into less rarefied domains. "Space stands for low-weight, robust, temperature-resistant technology that has to work," says Frank Salzgeber, head of technology transfer for the European Space Agency, which launched Rosetta. "Failure is not an option."

Rosetta is an extreme example, first because

of its decade-long journey through frigid, radiation-fried space to reach its target 800 million kilometres from the sun, and second for the fiddly operation to get its Philae lander on to comet 67P's rough surface. "Just imagine you ordered your car 12 years ago and got it 10 years ago," says Salzgeber. "You don't refuel it, it never gets any maintenance and you really treat it like shit: you go to the desert, to Siberia and then on the last day you go to Monza, the motor-racing circuit. The car's papers say it will run at 250 kilometres per hour, so you test it. And it works." For a time, anyway – a rather bumpy landing put Philae to sleep after just two days (see "Come in, comet", page 37).

One of Philae's tasks was to use a gas chromatograph to separate out organic compounds on the surface of the comet, and a mass spectrometer to compare them with those found on Earth. Mass spectrometers are

generally the size of a small fridge, but Philae's, called Ptolemy, is the size of a shoebox. It's no coincidence that the new bedbug detector, named APOLLO, is not much bigger and works along exactly the same lines. "I'm making an affordable version of Ptolemy," says Geraint Morgan of the Open University in Milton Keynes, UK, who helped design the Rosetta instrument. "Again we sniff, we separate and we detect."

Morgan is working on APOLLO as part of a spin-off company, Insect Research Systems, together with Jason Littler, a pest controller based in Manchester, UK. Some of the funding is coming from an ESA business incubation centre based at Harwell, UK, one of a network the agency has established across Europe.

Bedbugs beware

Whereas Ptolemy sniffs cometary gases, APOLLO is after pheromones released by bedbugs to attract mates and as a warning signal to others. Bedbugs were all but wiped out in the Western world after the second world war, but numbers have surged in recent years because of pesticide resistance and increased international travel. The detector is being tried out in hotels around Manchester.

Morgan is also involved in another sniffer spin-off. This time the aim is to detect



TIM FLAGGETTY

Good vibe: Space tech could soon aid heart bypass operations



DAVID SILVERMAN/GETTY

Helicobacter pylori, a bacterium that causes stomach ulcers and can raise risk of stomach cancer. In many developing countries where *H. pylori* is a particular problem, access to labs that can carry out necessary blood and breath tests can be limited. The company Oxford Micro Medical is developing a reusable, smartphone-sized alternative called a mass discriminator card. First the person being tested has to swallow a tablet containing urea labelled with a heavy isotope of carbon, carbon-13. If they are carrying *H. pylori*, it will break down this urea and the heavy isotope will wind up in exhaled carbon dioxide, where it can be detected by the card.

Like Insect Research Systems, Oxford Micro Medical is partly funded by ESA. Morgan says he and his team are “ironing out a few wrinkles”, but hope the card can go on sale in around a year’s time. He is coy about how much each card will sell for, but says its simple

“Space tech is low-weight, robust, temperature-resistant and has to work”

design means it would be “significantly less” than a standard mass spectrometer.

Other putative spin-offs using Rosetta’s gas-sniffing technology range from a system to monitor air quality on the UK’s proposed new fleet of nuclear submarines to a robotic nose that will “detect the complex, changing mixtures of airborne molecules encountered by consumers in everyday situations” – a device that the perfume company Givaudan wants to use in developing new fragrances.

The Ptolemy detector was delivered to the Rosetta mission in 2001, a few years before take-off, so Morgan’s multidisciplinary team

has had at least 15 years to refine the technology. It’s a similar story for Rosetta’s atomic force microscope MIDAS, which is helping to characterise the dust flung from comet 67P to form its tail. As a dust speck passes through MIDAS, a finely controlled needle gently scans the grain’s geometry, creating a three-dimensional picture of it.

The company that developed the system, Cedrat Technologies, based near Grenoble in France, is now using the needle’s sensitive actuators in a device for fiddly coronary artery bypass operations. Such operations usually require surgeons to stop the heart beating, with circulation maintained by a heart-lung machine. But the actuators of Cedrat’s Cardiolock device dampen down movements in a small area of muscle tissue surrounding the relevant artery, allowing the heart to continue beating. “A small lever connected to the actuator gently touches the heart and it tries to reduce the movement in the heart; it tries to calm down the area,” says Francois Barillot of the company.

Cardiolock has already shown promise in tests in pigs. More prosaically, the company is working with skiing equipment manufacturer Rossignol to see whether a similar system could make skis vibrate less at high speeds.

But while the spin-offs from Rosetta are numerous, that’s not always the case, much to Salzgeber’s frustration. “The ‘best’ missions for technology transfer are the ones that are cancelled, because then the engineers are forced to do something with the technology,” he says. Some countries and research organisations are better than others at encouraging spin-offs, says Salzgeber. “It’s about the recycling rate of your ideas, similar to the recycling rate of paper.” Get it right, though, and bedbugs worldwide beware. ■

Andy Ridgway is a science writer based in Bristol, UK

SPIN-OFFS FROM SPACE

Smoke detectors, water filters and memory foam are all innovations from the golden years of the space race – and the inspirations keep on coming

TOMATO BOOSTER

A European Space Agency spin-off, Giaura, based in the Netherlands, is hoping to find terrestrial uses for the porous beads that scrub carbon dioxide from the air aboard the International Space Station. The idea is to capture atmospheric CO₂ to boost the growth of greenhouse tomato plants, make carbonated drinks and cement or – in the first prototype – to pump it into aquariums to help keep water plants healthy.

FLAME-RESISTANT UNDERPANTS

“Thunderwear” – prototype flame-resistant bras and underpants developed by Swedish clothing maker Bjorn Borg in collaboration with ESA – was launched at a fashion show in Stockholm last year. Made from Nomex, a fabric used in spacesuits, Thunderwear emerged from discussions between ESA’s technology transfer team and Jernkontoret, Sweden’s association of steel-makers. Steel workers struggle with conventional underwear as cotton retains heat, and can easily catch fire from a stray spark.

DREAM GREEN HOME

A human mission to Mars would be a logistical nightmare, and NASA uses specially designed software, developed at the Massachusetts Institute of Technology, to analyse permutations of technologies for cost, mass and chances of success. Ekotrope aims to do the same for building firms. It juggles options such as types of windows and boilers, and levels of insulation, to find the best trade-offs between the annual cost of heating a home and the cost of building it.

The ultimate virtual archive

The Vatican Library’s collection of 180,000 manuscripts and 1.6 million books is being digitised using a system developed by ESA and NASA to store data from satellites. The Flexible Image Transport system was designed to be backwards compatible, so it will still be readable by computers even hundreds of years from now. The first 500 manuscripts digitised using FITS can be seen at digital.vatlib.it/en/collection.

Grape expectations

Think that mineral taste in your wine comes from the soil? **Chris Simms** digs around to unearth the secrets of terroir

IN THE dimly lit cellar below a London wine shop, a man gives his glass a good sniff. His nose plunges too deep and, for a moment, resembles an inverted iceberg, bobbing in a Chardonnay sea. Then he snorts, and his laughter destroys the illusion. “That,” says the woman leading the tasting, “is not how to nose your wine.”

As people start to get the hang of it, she asks us to shout out the flavours we detect. Everyone thinks they smell fruit. One woman says eucalyptus. Another tastes flint. Our oenological guide agrees, telling us that the mineral, flinty characteristic is a distinctive taste of this Chablis. “It comes from the limestone in the soil of the vineyard,” she says.

This story of how the Chablis got its taste is an alluring one – and it’s meant to be. For many winemakers, the key to keeping their share of the \$200 billion wine market comes down to the idea that local geography, geology, climate and winemaking practices, together known as the terroir, give a unique flavour to their wine. Thus their land is the only place you can make it. This idea forms the basis of wine laws around the world – it’s why champagne can come only from the Champagne region of France, for example.

But does the idea of terroir stand up to scrutiny? We have recently unearthed the roles of soil, water, temperature, microorganisms

and human practices in a wine’s taste, and the emerging picture sends a question bubbling to the surface. If you can discover what gives a great wine its *je ne sais quoi*, would it be possible to mimic it elsewhere, perhaps even from vines grown in your own garden?

The most common way of thinking about terroir is repeated by wine experts and normal folk alike as they sip their fine burgundy or supermarket plonk. “It is standard in wine descriptions to mention the geological nature of the soils, as though granite, limestone or whatever confers some special ingredient, unknown to science. Most vineyards claim their soils are unique and very special,” says Alex Maltman, a geologist at Aberystwyth University, UK.

In recent years, “minerality” has become a buzzword for these supposed mineral-like tastes. But there’s no known process by which minerals can make it from the soil to the grape and then into wine in high enough concentrations to be tasted. And even if they could, what would they taste of? “With the odd and fairly irrelevant exceptions like sodium chloride, by and large, minerals have no taste,” says Maltman.

“The idea you can taste minerals from the soil is absolute rubbish,” says Barry Smith of the University of London’s School of Advanced Study, who specialises in the

“The idea that you can taste minerals from the soil is absolute rubbish”

MOHAMMAD ITANI/MILLENNIUM IMAGES



The weird things in your wine

Some of the tastes in what you sip can come from unusual sources

Ladybirds

TASTE/SCENT:

Green peppers, bitter herbs

CAUSE: Methoxyphenols

Insects are accidentally crushed with the grapes, releasing methoxyphenols. In 2001, this caused Canadian winemakers to dump 1 million litres of wine

Eucalyptus

TASTE/SCENT:

Eucalyptus, spicy and cooling

CAUSE: Eucalyptol

If eucalyptus leaves get in with the grapes, they release eucalyptol when crushed. Some 40 per cent of Australian red wines contain detectable eucalyptol

Noble rot

TASTE/SCENT: Intense sweetness, honey, apricots

CAUSE: *Botrytis cinerea*

This fungus dries out the grapes, making them sweeter. Tokaji wine from Hungary, for example, gets its sweetness this way ➤

multisensory perception of flavour. But that doesn't render the word minerality meaningless. A drink's feel in the mouth could give you a perception of minerality, he says. Often wines are described as having a taste of wet stone or dry slate. "If you lick a slate, it has no flavour," Smith says, "but it does leave you with a dry feel." Tannins in wine can make your mouth feel dry, so it could be this sensation that sometimes brings slate to mind. You might also be detecting a hint of slate because you were expecting to taste it.

Au revoir, terroir?

So is that the terroir case closed? Not quite: it turns out that if you grow the same grapes in different places, the resulting wines differ chemically. Last year, Régis Gougeon of the University of Burgundy in Dijon, France, and his colleagues used mass spectrometry to look at Pinot Noir grapes and wine from plots just 2 kilometres apart in the Côte de Nuits region of Burgundy. They found that the array of fatty acids, cholesterol, flavonols, phenols and more in the grapes and wine from each vineyard showed distinct differences – a chemical representation of terroir.

What's behind this variation? One obvious answer might be the choices of the winegrower. Everything from the watering and pruning of vines, to choosing when to pick the grapes, which yeasts to use for fermentation or which barrels to age a wine in will affect the final taste. But Gougeon's two vineyards were run by the same person, so something else must be behind it.

Hints come from work by Rosa Lamuela-Raventós of the University of Barcelona and her colleagues. Comparing almost identical plots of red Grenache grapes in Spain, they ➤

have shown that wines coming from vines grown in richer soil have muted colours, fewer aromatic compounds known as phenols, and seem less likely to improve with age. That might go some way to explaining a belief common among winegrowers: to produce good wine, the vines must suffer.

Other factors also mean we shouldn't be so quick to dismiss the concept of terroir. Tiny organisms within the soil and elsewhere can also influence wine. It's well known, for example, that mycorrhizal fungi form symbiotic relationships with plant roots and help them get nutrients, says Greg Jones of Southern Oregon University in Ashland. And just as you have a microbiome of organisms that are crucial to your health, so too, it seems, does a vine, and these vary from place to place.

"If you grew a plant without any microbes, you wouldn't have any wine," says Jack Gilbert of the Argonne National Laboratory in Lemont, Illinois. "Bacteria and fungi influence the chemical composition of the grapes and the health of the vine."

Special reserve

The concept of microbial terroir in grapes was revealed in 2013 by Nickolas Bokulich at the University of California, Davis, and his colleagues. The group showed that the freshly pressed juice of the same types of grapes (they looked at Chardonnay, Zinfandel and Cabernet Sauvignon) from different regions of California have distinct microbial make-ups – and these change from year to year. Not only that, but each part of a vine hosts a different bacterial and fungal community.

Gilbert and his colleagues have now looked at the RNA of those bacteria for genes that a plant might find useful. They found that bacteria on the grapes, for example, have more genes involved in metabolism and chemical defence – perhaps against hungry insects – both of which could conceivably affect taste. The communities of bacteria living on the leaves, flowers and grapes have more in common with those in the soil than with each other, so Gilbert suspects that the plant is recruiting different microbes from the soil to help with specific jobs. And this reservoir of microbes varies with factors such as the pH of the soil, so it may vary between different plants and rows in a vineyard, let alone between vineyards and regions, says Gilbert.

Those microbes can be very influential. Many sweet wines like Sauternes or Tokaji

can be made only once grapes have been attacked by the fungus *Botrytis cinerea*, also called noble rot. This fungus is also associated with a compound called geosmin that can give wine an earthy or musty flavour, as can some bacteria that live on grapes.

Of all the microorganisms, it is yeasts that probably have the biggest effect on taste. During fermentation, yeast turns the sugar from the grapes into alcohol, giving rise to the 400-plus compounds dictating the taste, smell and mouthfeel of a wine. The "flint" that my fellow wine taster perceived in her Chablis is one example. "If a fermenting wine is starved of oxygen, then the yeasts produce sulphur," says Smith. "Just a bit and you get a smell like a struck match – people think it is flinty."

Many winemakers use starter cultures of *Saccharomyces cerevisiae* – brewer's or baker's yeast – for fermentation to ensure a uniform taste. But in recent years, there has been a move towards using the many yeasts naturally present in vineyards to bring out different

flavours – a further source of terroir. Some people even swear off pesticides to protect their yeasts. Work by Mathabatha Setati of the Institute for Wine Biotechnology at Stellenbosch University in South Africa and her colleagues shows that there may be something to this. They found more species of yeasts on grapes in vineyards run according to organic principles than in ones that use conventional pesticides and fertilisers.

Some species of yeast are known to contribute very distinct notes to a wine. A pungent, farmyard smell can be down to a yeast called *Brettanomyces bruxellensis* getting in at almost any point in the winemaking process. Most regard it as spoiling the wine, but some winemakers in Bordeaux and the Rhone consider it part of their wine's distinctive style.

Your own microbes can even play a part in what you taste. The bacteria in the saliva of people with obesity, for example, suppress the release of aroma compounds from wine. You too can be part of terroir.

Brett yeast

TASTE/SCENT:

Rancid barnyard smell

CAUSE:

Brettanomyces bruxellensis

This yeast can strike at any stage of the winemaking process. Some wineries, such as Château Musar in Lebanon, embrace its qualities

Smoke

TASTE/SCENT:

Smoke, wet ashtray

CAUSE:

 Guaiacol

Waxy skins of grapes catch smoke particles, which contain guaiacol. After forest fires in 2008, much of the Pinot Noir from California's Anderson Valley tasted smoky

Harvesting damage

TASTE/SCENT: Cat urine, boxwood, grapefruit, passion fruit

CAUSE:

 Thiols

Some of the signature tastes of Sauvignon Blanc are accentuated in Marlborough in New Zealand. Higher levels of thiols in grape juice seem to be linked to mechanical harvesting there



JEAN LUC CHAPIN/AGENCE VU/CAMERA PRESS

Looking beyond microbes, climate plays a huge, locally varying part in the taste of wine. Last year, Gougeon and his colleagues showed just how powerful a variable it can be. As well as pinning down a chemical representation of terroir, they looked at how this signature changes from year to year. Interestingly, the collection of compounds in the wines from

“Even microbes in your saliva can play a part in how you taste wine”

the two plots they studied were a closer match to each other in any single year than they were to wines from the same plot in a different year. In other words, the weather conditions in a particular year – the vintage – can trump other influences. These differences also increase over time. “The expression of terroir in the wine grows, or changes, in the bottle,” says Gougeon.

What is it about the weather that might be so influential? Temperature, rainfall and sunlight are just some of the factors that interplay to affect the health of a plant and the pace at which grapes grow and ripen. By doing this, they alter the proportions of chemical compounds within the grapes, affecting what goes into the fermenting tank and thus what the yeasts will kick out. Broadly speaking, wines from cool climates tend to have a subtle, crisp taste and lower alcohol, while wines from hot climates are heavy and bold with more alcohol.

The climate’s influence has many viticulturists uneasy about the future. Wine production typically happens in areas where the growing season’s average temperature is between 12 and 22 °C. Over the next few decades, climate change will affect temperature and rainfall across much of the world, conceivably altering which regions are most suitable for growing certain grape varieties. “Can Pinot Noir perform in warm climates?” asks Jones. “Probably not. It is

grown at the limits in Oregon, Washington, Tasmania and New Zealand. These areas could lose that ability.”

Other big names could also be hit. “Champagne is magical because it is cool in the region,” says Jones. “Warmer weather would make it more difficult to create that distinctive taste there.” Microbes could help, says Gilbert. Finding the right bacterial helpers could increase the resistance of plants to a changing climate. Or growers could swap to grape varieties better suited to the new conditions.

How Merlot can you go?

What we’ve covered so far can’t explain all the interesting flavours in wine, though. It has long been wondered, for example, why some wines have a hint of eucalyptus. In 2013, the Australian Wine Research Institute declared it was down to eucalyptus leaves being picked up with the gathered grapes and releasing the odorous compound eucalyptol when crushed.

And a bitter, herb-like smell and taste, sometimes described as being like green peppers, can be caused by ladybirds – and the methoxypyrazines they release – getting bundled in with the harvest. The taste of smoke can even piggyback into wine when the waxy skins of grapes catch particles from the smoke of forest fires, says Jones.

But back to the big question. Now that we can separate out some of the taste influences in a wine, could we copy a 1998 Château Margaux, with its notes of berries, smoke, green pepper and earthiness? Do you just need Cabernet Sauvignon vines, some not-too-warm weather, a nearby fire, a handful of ladybirds and a sprinkling of fungus?

Rivalling great wines can certainly be done, says Maltman, as is shown by the success of many New World wines. But to mimic one exactly, you would have to know all the variables – and some might be hard to identify. “Lots of wine companies are interested in protecting their own flavours,” Gilbert says. “If you uncover the secret that makes their microbiome and wine so awesome, maybe they’re not going to be very happy.”

It’s hard to argue that replicating your favourite Bordeaux would be easy. But there’s enough information out there to give it a good go, and all winemakers have to start somewhere. Perhaps it’s time to look for a patch of ground and do some experimenting. And then... que Syrah Syrah. ■

Chris Simms is the chief subeditor at *New Scientist*

Can we sue the web?

Tim Maughan finds medieval answers to digital questions at the hippest event in town

Conference: Theorizing the Web
17/18 April, International Center of
Photography, New York City

THIS century's next great legal challenge will be to make those responsible for complex systems accountable for their actions, says Kate Crawford, who works for Microsoft Research. If a bunch of unrelated algorithms, interacting in unforeseen ways, puts you under heightened surveillance, blocks your credit or stunts your kids' life choices, who do you call? Who will make redress for such unforeseen, unintended automated wrongs?

There are no clear answers to these questions, which is why Crawford wants to resurrect the deodand, an obscure legal term from the 11th century.

Only at a hip New York conference like Theorizing the Web could medieval law be proposed as the answer to the great legal battle of our age. Now in its fifth year, the event is widely regarded as the coolest kid on an already crowded block. Its participants are dressed more for a music festival than an academic conference. They are sociologists who code, coders who do social theory, hackers who make art and artists who hack. Who else would listen to an exegesis on deodands in the bare, unfinished venue for New York City's International Center for Photography, with dusty floors and terrible acoustics that are better suited to a rave?

In medieval England, personal property became a deodand if it was judged responsible for the

death of a human being and, as such, was forfeit to the monarch. Its owner was ordered to pay a fine equal to the object's value to the court. Everything from haystacks to pigs and horses were declared deodands. The practice was revived in the 1830s to hold railway companies to account for train deaths, but paying a fine equal to the value of an expensive train every time someone died in a crash proved unworkable.

Crawford argues that the deodand was killed off by corporate capitalism's ability to shape its own legal accountability. She says we must be wary of allowing technology companies to use unseeable complexity as a reason to wash their hands when things go awry.

Her talk left me wishing that I had a more solid understanding of the way we interact with technology to hold the right people to account.

The hipness of Theorizing the Web comes not just from the youthfulness of its participants but also from the newness of their work. Many of the delegates were presenting work in progress, or the results of as-yet-unfinished doctorate theses.

Our continuing post-Snowden obsession with privacy and surveillance loomed large at the conference. For instance, Joshua Scannell at the City University of New York analysed Microsoft's

"Efficiency is always draconian, and good intentions never survive algorithms"



NIAL MCDERMID/MILLENNIUM IMAGES, UK

It's behind you! There's always a camera you don't know about

Domain Awareness System, a smart city crime monitoring and prediction system developed in association with the NYPD. By collating public and police information with data collected by sensors across the city – including radiation sensors sensitive enough to pick up recent chemotherapy treatment – the Awareness system creates “heat maps” of risk.

“The absence of sensor data is not the absence of information,” Scannell told the conference. A lack of credit card transaction

activity in a neighbourhood, for example, allows the system's users to make judgements about that area's residents, their levels of wealth or poverty, and to then associate them with the potential for crime.

This system is a tech-savvy, yet sociologically simplistic form of social labelling. Reducing human activities to metrics is being marketed as a way to combat racial and social bias. But such pigeonholing feeds reactionary policies as efficiently as it informs other kinds. Efficiency is always draconian, and good intentions never survive algorithms.

Nestled between ageing stores



selling white goods and the restaurants of Chinatown, the centre is a few doors from the Bowery Mission homeless shelter. Like most of New York, this neighbourhood faces a wave of gentrification – a process often typified by hip young people standing around in bare, dusty art spaces. How long before rising rents put the kitchen stores out of business and make them as bare and dusty as this venue, I wondered. Presumably, the Chinese restaurants will then buy their fridges and ovens online. ■

Tim Maughan is a writer based in New York

Take a look at your self

Why are we so distracted? Blame the Enlightenment!

The World Beyond Your Head: How to flourish in an age of distraction by Matthew Crawford, Viking, £16.99/\$26
The Four-Dimensional Human: Ways of being in the digital age by Laurence Scott, William Heinemann, £20

Reviewed by Mike Holderness

TOYS, toys, toys. We are deluged with new playthings that make ever more demands for our attention – many of them digital. How can we focus on anything true or beautiful amid the twitter and chirp of such constant, almost toddler-like demands?

Other writers have excoriated the distractions of ubiquitous technology and advertising. But Matthew Crawford seeks a deep philosophical perspective. He has a background in physics and political science, and is now at the University of Virginia's Institute for Advanced Studies in Culture. In *The World Beyond Your Head*, he explores how we got to what he calls a "crisis of attention". His onslaught starts with nothing less than an attack on the "Enlightenment self", because, it seems, it is the isolated self that permits distraction.

Immanuel Kant's ideas are frequently taken to be the epitome of the 18th-century philosophical Enlightenment, and Crawford blames him for constructing its notion of the self as an isolated being for whom true knowledge can arise only from solo enquiry.

He spreads the blame to the 17th century – to John Locke, the font of liberal thought, and to René Descartes, who said that the only thing he couldn't doubt was that there was something, a self, doing the doubting.

Oddly missing is any discussion of another key Enlightenment

figure: Adam Smith, who theorised capitalism as an economy of atomised individuals making rational choices in a social vacuum. "Freedom" and "choice" are the mantras of capitalism. Even though "we often assume that diversity is a natural upshot of free choice", Crawford says, "the market ideal of choice... tends toward a monoculture of human types: the late modern consumer self." As an example, he describes how lobbyists for casino gambling "tap into the deep psychology of autonomy" to make it seem that submitting to the engineered attention-grabbing of gambling is a human right.

All this introduces us to one of Crawford's key proposals for dealing with the crisis: to shift our focus from the lonesome atomised individual to truly shared attention. The current fashion for the "wisdom of crowds" is not true sharing, but rather the market mining individuals. As he writes, "there is a lot more money to be made as an aggregator of 'content'

than as a producer of it".

Crawford's core message is that we should stop focusing on ourselves and move towards true sharing. "Involve your ass, your mind will follow," he says. He commends to us the "flow" he feels when riding a motorbike, when his derriere is deeply involved in his need to pay attention. He feels it too in his workshop, making motorbike

"Crawford proposes shifting our focus from lonesome Enlightenment individual to shared attention"

parts and solving problems with others. In particular, he says, we should value education as a face-to-face apprenticeship in the ways of investigating and of making, through attention shared in person. He gives as an example learning to build a pipe organ, with the person who has to repair it in 400 years' time in mind.

You will find a much gentler and more literary exploration of the ills of distraction in the musings of Laurence Scott, who teaches creative writing at Arcadia University in London.

In *The Four-Dimensional Human*, Scott reaches out not into space-time, but into the 20th-century literary imagination's grasping for something outside the mundane three dimensions.

His account of what is becoming of us is often beautiful even if unnerving at times, such as when he evokes the web pages that come alive on anniversaries of their owners' deaths. It is certainly worth our attention. ■

Mike Holderness writes about science, technology and philosophy

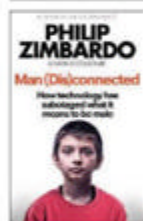


SOLSTOCK/GETTY

It's a guy thing

A lament about men's plight leaves **Chris Baraniuk** puzzled

Man (Dis)connected: How technology has sabotaged what it means to be male by Philip Zimbardo and Nikita D. Coulombe, Rider, £12.99



"I'M HERE to alarm," announces Philip Zimbardo, a towering figure of 20th-century psychology. Zimbardo is famous for the

1971 Stanford prison experiment, in which students role-played as guards and inmates. The study was called off after six days, but not before the "prison officers" began to treat their "detainees" sadistically.

Today, Zimbardo is more concerned with what he sees as society's attack on guys. His latest book, *Man (Dis)connected*, is stridently subtitled "How technology has sabotaged what it means to be male".

But after 90-odd minutes in Zimbardo's (always engaging) company, and having read and reread his book, I am not much closer to understanding it all. And of the bits I do get, I am fairly sure that some are wrong.

To begin at the beginning: men's plight is not entirely without evidence. A recent large study by the Organisation for Economic Co-operation and Development shows that males are often left far behind girls in literacy and most exam results, and retain only a slight edge in maths.

Zimbardo blames video games and porn, because these are solitary activities that stunt boys' social development and entice

them into a self-contained world that is more exciting, but also less challenging than the real one.

These are good provocations, and worth exploring. Certainly, children's consumption of extreme porn is troubling. But why are men so susceptible? And how frequently is a compulsion to consume porn the real cause of a corroded relationship?

Zimbardo cheerfully admitted that he does not actually play any video games, so I took him to task. There is no doubt that the addictive qualities of gaming are of concern, but what about the newer phenomenon of in-game socialising and interaction? He replied: "That's happening less and less." Does he really not know about those massive multiplayer online games that rely on people's ability to work in a team and solve problems together?

In 2011, Zimbardo delivered a TED talk called "The Demise of Guys?" Nikita Coulombe came on board to help write it up for an

ebook and conduct the surveys and many of the interviews on which *Man (Dis)connected* is based. The more we talk, the more I wonder if I am interviewing the wrong author.

Coulombe has assembled disturbing statistics, particularly on men's higher education, so why does the book highlight the fact that women now achieve 52 per cent of all PhDs? Why use this

"How come women are immune to the very forces that are out to destroy me?"

innocuous disparity to exemplify men's wholesale decline?

The pile of unanswered questions grows. Is there something about men that draws them to experiences that cut them off from schoolwork and relationships with women? Is technology to blame, or is their increasing dependence on it a symptom of something else?

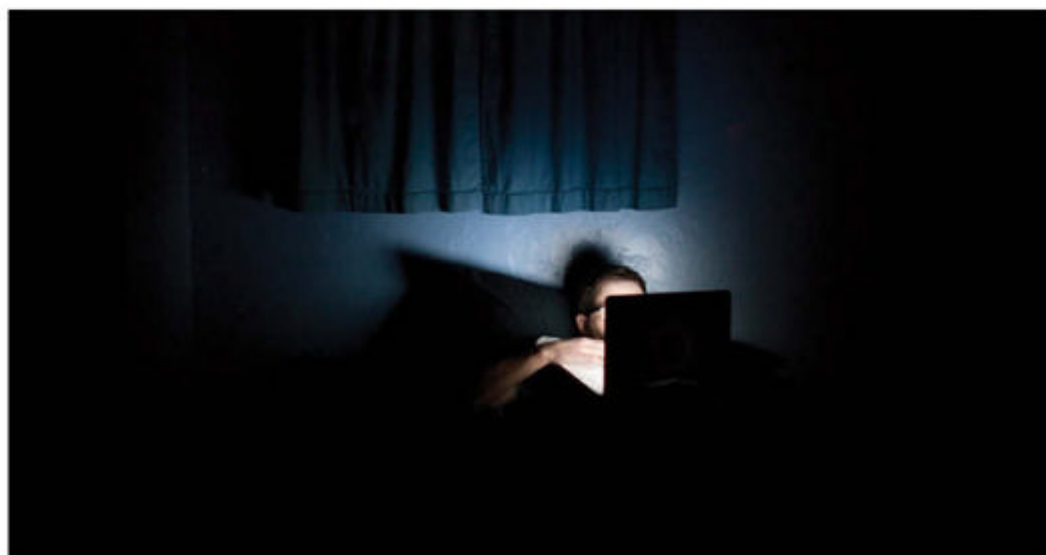
This being a book about men,

we do not hear about women's experience of porn, or games, or, indeed, higher education. And this is the problem: by making this book about gender (rather than technology, education or porn), the authors render men passive. Women's lives look positively rosy by contrast, because we don't get under their skin.

I had thought this book would make me understand my own sex better. Instead it left me wondering whether I understood women: how come these creatures are immune to the very forces that are out to destroy me?

We read a lot in Zimbardo's book about how the world is unfair to men, and how they spend their time chasing all kinds of ineffectual pursuits and avoid reality and responsibility. But where does this spring from? That is the question we must answer if we're serious about saving guys. ■

Chris Baraniuk is a freelance science and technology journalist



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GYNECOLOGICAL CANCER RESEARCH POSITION Department of Pathology

The Department of Pathology at the University of Alabama at Birmingham (UAB), in collaboration with the UAB Comprehensive Cancer Center, is committed to building an active research program in the area of gynecological cancer. We are therefore inviting applications for a tenured or tenure-track faculty position at the Associate or Full Professor level from scientists (Ph.D., M.D., M.D./Ph.D.) depending on experience, research and scholarly accomplishments. Applicants should have an actively funded research program in the area of gynecological malignancies. Successful candidates will have a demonstrated record of originality and productivity in research with existing NIH funding as well as a commitment to graduate education in cancer biology. Exceptional candidates will be eligible for appointment to the Hazel Gore, M.D., Endowed Professorship in Gynecologic Pathology. UAB, which ranks in the top 25 in NIH funding, is a dynamic, collaborative research institution with state-of-the-art facilities, excellent graduate programs, and a commitment to post-doctoral education. Faculty will be expected to participate in the training of graduate students. The candidate will be appointed as a member of the Division of Molecular and Cellular Pathology in the Department of Pathology. A pre-employment background investigation is performed on candidates selected for employment. Interested candidates should submit a cover letter that includes research interest/experience, a curriculum vitae, and the names of three references to: Ralph Sanderson, Ph.D., Chair of Search Committee, Professor, Division of Molecular and Cellular Pathology, Department of Pathology, email PATH-MCPFRecruit@mail.ad.uab.edu

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Purpose

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Role Accountabilities

The role will be based in Shell's Projects & Technology Group, located in the Shell Technology Center, Houston, Texas. The successful candidate will work within Shell's in-house Microbial Biofuels team, scaling-up Shell's proprietary ligno-cellulosic biofuel process from the bench to production scale. The challenges in such a process range from soil carbon and ecosystem services analysis, through enzyme hydrolysis, solid and liquid phase fermentation, to molecular microbiological transformations.

Potential candidates will be engaged in a range of activities such as: ecosystem service modelling, molecular transformation, microbial pathway evolution, enzyme hydrolysis, novel fermentation, and organism research.

Responsibilities will include: design and implementation of experimental programs aimed at producing commercially viable biofuels from micro-organisms, taking into account a wide range of contributory factors; and identifying opportunities and engaging with the development of commercial plans.

Candidates are expected to have excellent intellectual and analytical ability, the enthusiasm to progress their insights, strong teamwork and leadership skills, as well as the ability to broaden outside of their area of expertise. The successful candidate will be expected to work with Shell engineers globally, as well as with external partners.

Required Qualifications/Skills

Ideally, the successful candidate will have a PhD (or be in their final year/ write-up of a PhD) in one of the following areas, or a related field:

- Microbiology
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They will have demonstrated a willingness to learn and apply cross-discipline approaches to solving problems, and be happy working in a tight-knit team.

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- Soil carbon pathways and sequestration
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- Enzyme hydrolysis
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- You must have a minimum Cumulative GPA (CGPA) of 3.20.
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- In the "Students and Graduates" section, click on "Shell Recruitment Day" and then create an account. When entering your contact details, select "Other" in response to "Where you found out about this Shell opportunity," click "Next" and then type in "Biodomain Researcher."
- We require a completed application, an updated copy of your résumé and an unofficial copy of your transcripts / grade report prior to be considered for an interview.



Knowledge that will change your world

The University of Alabama at Birmingham

DIRECTOR, DIVISION OF INFORMATICS Department of Pathology

The University of Alabama at Birmingham (UAB) Department of Pathology is seeking an outstanding candidate at the **tenure/tenure-earning Associate Professor or Full Professor** level with experience in the field of biomedical informatics to lead its Division of Informatics. Extensive experience in biomedical informatics, or bioinformatics/computational biology and a **M.D. or a Ph.D.** in a related professional field is required. Candidates must have a demonstrated expertise in one of the areas of biomedical informatics and the ability to retain extramural funding. He/she will work across departments, centers and schools to enhance medical informatics, public health informatics and bioinformatics at UAB.

Four years ago, the UAB School of Medicine committed significant resources to the establishment of a Division of Informatics in the Department of Pathology and the implementation of a campus-wide clinical informatics infrastructure. During that time the division grew to five faculty, hosting multiple informatics resources in sequence and image analysis, and offering a suite of well attended immersive courses in Biomedical Informatics and Computational Pathology for both medical and graduate trainees. The new Director will be expected to continue the expansion of the Division through additional recruitment and new investments that further advance its research, education and service portfolio. The Director will participate in the development of two new Institutes at UAB, Informatics and Personalized Medicine.

The UAB-School of Medicine is located in Birmingham, AL and is ranked 26th in NIH funding. The UAB Health System is a >\$2 billion/year enterprise, consisting of University Hospital (981 beds; with installed Cerner enterprise software), The Kirklin Clinic (1,100 physician group practice), VIVA Health (a regional HMO), UAB Highlands Hospital (specialty hospital), Prime Care (primary care network), and affiliated hospitals in Montgomery and Bessemer. UAB has established high performance computing and high speed connectivity to the Lambda Rail, as well as supports the Alabama Supercomputer Facility in Huntsville, AL. The UAB Comprehensive Cancer Center, together with its partner HudsonAlpha Genomics Research Institute in Huntsville, is a key participant in The Cancer Genome Atlas.

The position offers an excellent and comprehensive compensation and benefits package. All inquiries should be directed to: **Kevin A. Roth, M.D., Ph.D., Robert and Ruth Anderson Professor and Chair, Department of Pathology, UAB, 619 South 19th Street, WP 210, Birmingham, AL 35233-7331 email: path-informdir@mail.ad.uab.edu**. Interested applicants should submit: 1) a cover letter; 2) curriculum vitae with the names of three references; and 3) a statement of research interests.

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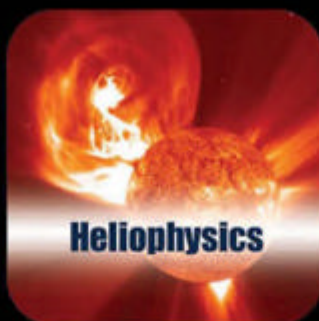
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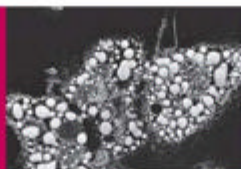
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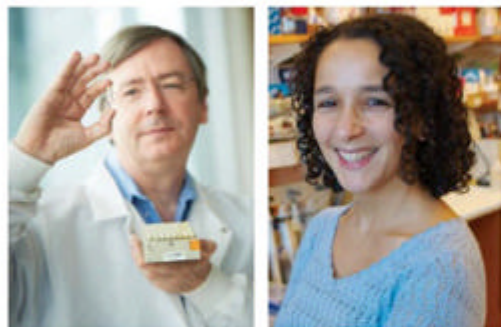
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EDITOR'S PICK



A probable Bayesian court

From Derek Bolton

Allan Reese's letter discusses an approach to what happens in courtrooms using Bayesian statistics, and asks what prior probabilities jurors bring to the cases they try (11 April). If we accept a Bayesian approach to verdicts, the jury should be given all the evidence, along with information regarding how each part affects the likelihood of guilt.

But in the existing system, some evidence is withheld: for example, previous convictions are concealed in the interests of maintaining the presumption of innocence. In most cases, juries are still likely to set much store by the very fact that the police singled out this individual. If there were prior allegations for similar offences, that fact is likely to have contributed to that choice, so may yet indirectly influence the jury.

Would it not be useful for juries to know how the defendant was singled out: because of previous charges, whether convicted or not; by a trawl of a vast DNA database; or in a far more select group of cases by anonymous tip-off? Juries may, however, be poor at assigning significance to evidence, including eyewitness accounts. *Sydney, Australia*

To read more letters, visit newscientist.com/letters

The price of not sequencing babies

From Bryn Glover

Helen Thomson discusses some concerns about sequencing babies' genes (11 April, p 8) but does not mention the effect on the future cost of healthcare for the babies concerned.

In countries such as the UK where the principle still (just) holds that free healthcare is provided from taxation solely on the basis of need, this should not be a problem. But in countries that rely to varying extents on commercial insurance companies to pay for people's healthcare, the existence of full genome information would have quite different implications.

It is well established – at least in folklore – that employers not only check job applicants' social media accounts, but also look askance at applicants who do not have such accounts; what have they got to hide? Might not the same attitude develop among health insurers when good healthy genomes attract a discount, with those who make no sequence available being penalised as potential bad risks? *Glasshouses, North Yorkshire, UK*

Could killer robots be more humane?

From Adrian Ellis

In your article on the moral dangers of autonomous, lethally armed robots, Peter Asaro says "most people now feel it is unacceptable for robots to kill people without human intervention" (18 April, p 7). The moral reasoning behind this view is intriguing. How is sending a programmed, armed robot into an area designated as "enemy occupied" any worse than, say, bombing the area from 10 thousand feet?

In fact, the level of precision and the amount of human

judgement involved in target selection with the robot would arguably be greater.

There is an even stranger moral angle. Someone who is ordered to go and kill strangers in a war can suffer severe emotional trauma and other mental distress as a result. In the future, there may be societies that decide, on moral grounds, to delegate all killing of the enemy in their wars to fully-autonomous robots so as to protect their citizens from such emotional trauma. In that unnerving scenario, the bots wouldn't be seen by those citizens as devils, but heroic guardians. *Hampton, Middlesex, UK*

From Rolf Pettersson

As I consider the question of whether we can control killer robots, I also ask: will a killer robot panic and shoot at everything in sight? Will it kill when in doubt? Will it suffer battle fatigue and shoot in uncontrolled rage?

I suggest that in future soldiers should not be authorised to kill without robotic supervision, rather than the other way around. *Hörja, Sweden*

A robot workforce would not work

From Anthony Castaldo

It seems plausible that within a century the vast majority of work-a-day jobs may be replaced by artificial intelligence (4 April, p 18). As a computer scientist, I have yet to see one that can write code, or a compelling novel or movie: but the creative arts are a rather thin slice of work.

People, from pilots to personal care attendants, who don't have to invent something new every day are candidates for replacement.

What happens when 95 per cent of jobs are done by machines at 3 per cent of the cost of a human (over their serviceable life)? What happens when the labour, attention or ability to think of

the vast majority of people is no longer worth paying for, because a robot can do it better for next to nothing? At some point enough people will be replaced to cause economic hardship and perhaps revolution, demanding some entitlement to the fruits of robot labour in order to survive when all the non-creative jobs are gone. *San Antonio, Texas, US*

From Joseph Oldaker

Every article on how drones, robots and algorithms are going to replace human workers seems to end with worrying about how people will cope with the increased leisure, instead of moving to the next step, which is worrying how people will cope with not having any money, because they haven't got a job. How will they afford the goods, services and, indeed, the robots?

This is not just a question of inequality between the rich and the rest. Consumer capitalism is unsustainable if you eliminate paid workers: who will consume the product?

Nuneaton, Warwickshire, UK

Too little noise on ocean commotion

From Gillian Coates

It would have given my husband, Rodney Coates, great pleasure to have read Sandrine Ceurstemont's lucid and comprehensive report on noise in the ocean (11 April, p 38). For many years he taught underwater acoustics to those in defence, the oil industry and environmental disciplines.

It is heartening to see that this work is still progressing and its importance is being recognised. However, political circles and the public are still ignorant of anthropogenic marine noise. The assumption is made that if something is placed "off shore" it will have little effect on us or on the environment.

Trefor, Anglesey, UK

f “It’s a shame. Her theorem is the most beautiful one in analytical mechanics”

@JasonVerve Tweets on Emmy Noether’s undervalued work on symmetry (25 April, p 33)

We believe we are rational humans

From Ray Norris

According to Graham Lawton, “Beliefs, more than anything else, are what make us human” (4 April, p 28). I guess I’m not human, then, since I decided as a geeky astrophysics student many years ago to live in an evidence-based world in which beliefs are replaced by working hypotheses.

At least, I think I did, unless somebody produces strong evidence to the contrary. Once you renounce beliefs, life seems very straightforward, and totally self-consistent. I don’t believe in global warming, but I think there’s strong evidence to support it. I don’t believe in the scientific method, but it seems to work remarkably well, so far. I don’t believe in god, but wouldn’t it be awesome if somebody produced evidence for a god? (I invite gods to try their hand at this).

A world without rigid intolerant belief is probably a gentler, kinder, more fault-tolerant world, with less persecution of those who

don’t share our beliefs. Whether you have (irrational) beliefs or (evidence-based) working hypotheses probably makes little difference to daily life, but an enormous difference to the way you view the world. I am always aware of the possibility that anything I say, including this sentence, is wrong.

Racism, sexism and all the other nasty-isms could probably not survive without belief. Unless I believe I’m superior to you, it’s very difficult to justify killing you, or discriminating against you. *Baulkham Hills, New South Wales, Australia*

From Alan Wells

While I was interested in the detail of how we perceive our personal “reality”, there was little mention of the connection with mental disorders. Studying these might illuminate our understanding of belief and lead to insights into treatments. The list of irrational beliefs held by significant percentages of people in the UK overlapped to a worrying extent with beliefs held by people deemed to have mental disorders.

Indeed, often acting in “logical” accord with their beliefs and perception of reality, in a manner that puts themselves or others at risk, is what leads to people being perceived as “ill”.

Many mental disorders involve distortion of belief. People who have anorexia do not believe what they see in the mirror, for example. It seems that a substantial proportion of the UK population might thus be considered to have a subclinical mental disorder. Society would, however, be a more boring place if all eccentrics were obliged to take psychiatric panaceas. *Chichester, West Sussex, UK*

Oblivious joggers running on auto

From Peter Lavers

Describing electrodes that can control people’s legs, Evan Peck says that such app-run systems will stop people being chained to their smartphones (11 April, p 18). But instead of attending to a navigation app, they will be on

Facebook – or Periscope (11 April, p 19). Next, will joggers run on auto, watching a feed of a golden beach rolling by?

Imagine all this coordinated in the cloud so people don’t collide. What a risk to those not linked in, with people whizzing about them oblivious to their surrounds. *Canberra, Australia*

Virtual tourists from the future

From David Heslip

Adrian Ellis suggests using virtual reality at pop concerts (Letters, 28 March). Could the perceived absence of time travellers be due to them using VR, so as not to frighten the locals? *Alicante, Spain*

Keys, wallet, passwords...

From Lawrence D’Oliveiro

It is a waste of time trying to come up with clever algorithms for generating easy-to-remember passwords (21 March, p 28). Choose hard-to-remember ones, by all means – and write them down. You know how to keep your credit cards and house keys safe. Put passwords in the same place. *Hamilton, New Zealand*

For the record

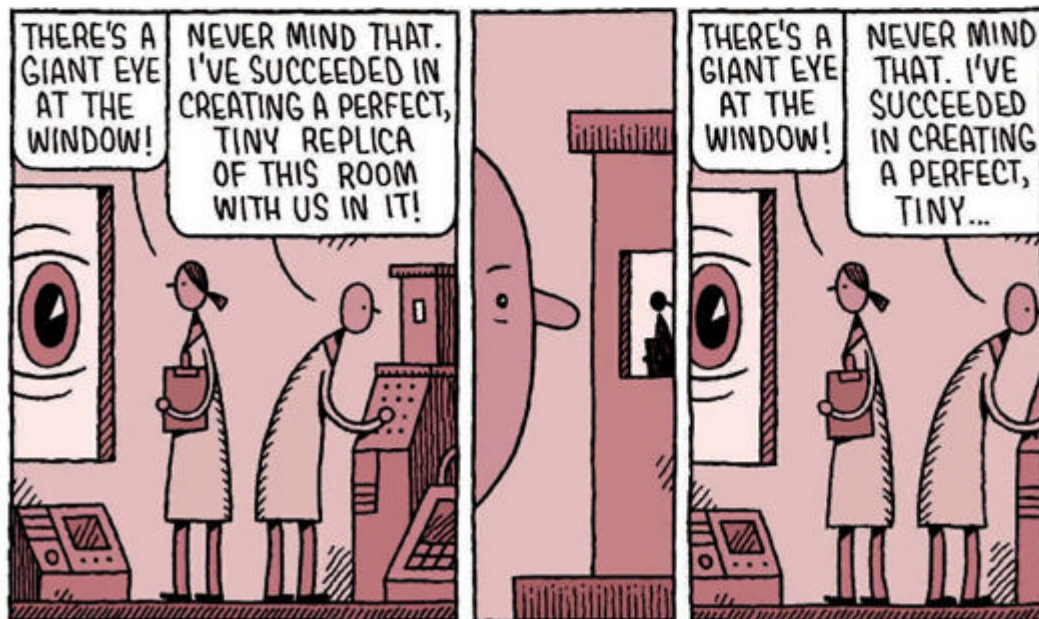
■ Messenger is a smallish space probe: the crater it made on Mercury is an estimated 16 metres wide (2 May, p 6).

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TOM GAULD





PLUCKY little Philae's epic and lonely struggle against the absence of gravity ensures that at least some of us are gripped by its stalled quest (6 December 2014). Will it wake? The most hopeful estimates are that now is the time to listen (see page 34).

Feedback will not join what one journalist colleague called "the idle speculation". Instead we turn, not for the first time, to the words of John Lennon: "Please, don't spoil my day, I'm miles away / And after all I'm only sleeping." Now we know why these lyrics featured on the album *Revolver*.

CLOSER to Earth – indeed, several metres beneath it – we have the raid on the Hatton Garden Safe Deposit Company in London, which netted a quantity of valuables that is undisclosed, not least to the tax authorities. The BBC captioned a photo thus: "The image shows the hole made using a heavy-duty drill, a Hilti DD350. It measured 50cm (1.64ft) deep, 25cm (0.8ft) high, 45cm (1.5ft) wide and 89cm (2.9ft) tall." Within minutes four readers had written

in. Arthur Chance's representative query was: "The only question is, if they can make 4D holes, how come they didn't just step round the wall?" We refer readers to any good book on multidimensional topology for explanation.

The BBC naturally retro-proofread its story smartish. Paul Cooper, however, found that archive.org had preserved the rather more interesting version.

MOVING away from Earth again, probably, we have further thoughts to report on the numerological or other significance of 187.5. This number seems mysteriously to recur in measures of the frequency dispersion of fast radio bursts (18 April).

Richard Chapman responds to Chris Conklin's observation that 1.875 is the smallest positive solution of the equation $\cos(x)\cosh(x) = -1$ by suggesting investigation of a 10-dimensional analogue of this formula, which we shall not write out. "It could shed some light on a possible metric amongst the 10 dimensions of string space," he proposes.

Fiona Vincent suggests that, contrary to our first assumption that 187.5 is a pure number, it has units: centimetres⁻³ parsecs, which she describes as "the sort of convoluted unit that astronomers love". Had they chosen to express it instead in, say, inches⁻³ light-years, Fiona says, "the common factor would have been 10,020". We're looking into that.

SEARCHING for references to 187.5 in our comprehensive piling system led it to throw up instead a thought about the challenge of presenting numerically based news. Consider the plight of Geraldine Bedell, founding editor of Gransnet, a website for grandparents, asked to comment on a policy proposal floated in 2012 by George Osborne, then chancellor of the UK's exchequer. This boiled down to replacing the policy "if you are a pensioner, then you are entitled to a winter fuel allowance" with... well, with an arithmetically complicated set of means-testing calculations to decide eligibility.

Geraldine told the BBC: "We know that whenever you have means testing you get a cliff edge", which is a reasonable summary of the arithmetic effect. "And very often the wrong people fall off the cliff," she went on. So which grannies would fall off?

INATTENTION has led us to discover an accidental random-text generator. We went to an online translation engine and started typing English into the "source" field on the left - not noticing that it was expecting Arabic. Typing "This is not Arabic" produced a string of Arabic text on the left and "This Is Whoosh Net wears" on the right-hand side.

This doesn't seem to work in Hebrew - although typing in "This is not Hebrew" produces "This is not English", which suggests someone somewhere has been thinking about how it might work if it did. In Russian we start to get a direct transliteration of "This is not Russian", which is amended as we type, in the style of "did you mean..." suggestions, then

translated as "This IP chickpeas Rusin". Probably, there's a use for this... maybe.

THE latest missive from oh-so-caring Christian Concern arrives: "Demo at hustings to protest anti-free speech Diane Abbott". The Freudian typo blunts the group's objection to the MP's objection to pickets outside abortion clinics...

FINALLY, another email caused us a double-take: its coming from the address info@rna.org made us expect something biomedical. Instead we read: "Students: submit religion news stories for \$600 award."

It seems rna.org is the site of the Religion Newswriters Association, and has been since 1997. Three-letter domains are quite the thing on the web these days: but the Religion Newswriters got to rna.org before, for example, masociety.org.

They are not the only obscure virtual claim-staker. We note that



belllabs.com is owned not by the famed research labs, but, since 7 August 1995, by Bell Laboratories Inc. of Madison, Wisconsin, which bills itself as "the world leader in rodent control technology". The more famous labs registered Bell-Labs.com on 10 January 1996. We wonder how many other organisations that should have known better wound up stuck with second-choice domain names.

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Peter Gunn sends an ad, hinting at a revolution in biology, for "plant-derived placenta cream". "Green technology cosmetic science containing ancient mysteries"; it goes on...

Preying alone

Many mammals such as wolves and lions are pack hunters. Many fish and cetaceans also collaborate to herd shoals into bait balls, then eat them. So why are there no flock-hunting birds of prey?

■ Your questioner is mistaken in believing that there are no flock-hunting birds of prey. The Harris's hawk (*Parabuteo unicinctus*) is well known to hunt in family groups of up to 14, but typically only five or six, in much the same way as the land mammals cited. This practice suits birds hunting in the desert and dry scrub landscapes of the hawk's typical habitat. Harris's hawks ambush prey by chasing their quarry into a group of waiting birds. During the chase, any hawk can take over when the leader gets tired or is thrown off course. They are reputed to be the most successful predators on the planet in terms of ratio of kills to hunting attempts, and share their spoils among the group.

Because of a gregarious nature, they have been widely adopted as falconry birds – they are relatively easy to breed in captivity and can be trained to attack a variety of game. They are sometimes flown by falconers in a “cast” of two birds, or even three, to take advantage of their natural behaviour.

David Ridpath

Drybrook, Gloucestershire, UK

■ I visited a falconry near Perth, UK, a few years ago and was

introduced to Oscar, a Harris's hawk that was adept at working with novice falconers. A falconer told me that these hawks are unusual in that they hunt in flocks, and that this might be the source of their flexibility and social intelligence in working with humans. I recall walking up a hill and being surprised to find Oscar

“The Harris's hawk is well known to hunt in family groups in much the same way as land mammals”

walking beside me. I was told he probably only wanted a lift to the top, and I let him stand on my glove. When I got to the crest, he took off again. He was obviously as tired as I was.

Robert Williams

East Croydon, Surrey, UK

■ My observations on our farm over many years indicate that birds of prey do collaborate and enjoy potential “meals”. I have seen wedge-tailed eagles work in pairs to stalk wild ducklings in open paddocks. Even though the ducklings were in the care of their parents and the adult ducks tried to protect their young, they were no match for the eagles.

We regularly observe crows acting in packs to secure their next meal, especially at lambing time. A number of crows will stand a short distance from a ewe with a very young lamb, patiently waiting for either the lamb to wander off from its protective mother, or the ewe to wander off

without the lamb for water or to feed. If either happens, they act quickly and attack the lamb. I have also observed dozens of crows in a flock chasing small mobs of ewes and young lambs in open paddocks, trying to separate them and attacking any lambs that lag behind. Is this why a group is called “a murder of crows”?

Anna Butcher

Brookton, Western Australia

■ The American white pelican (*Pelecanus erythrorhynchos*) will gather in flocks to herd fish if the water is shallow. When the water is deeper, the birds will usually hunt as individuals.

David Rubin

Ballston Lake, New York, US

■ Cooperative hunting in packs is actually rare among mammals, and seems to occur in intelligent and socially complex species in which the bond between related animals persists into adulthood. Hence, it is far more common for mothers and subadult offspring

“I have observed dozens of crows in a flock chasing small mobs of ewes and young lambs in paddocks”

to hunt together. The most familiar pack hunters are wolves, lions and orcas.

For this type of hunting to be a benefit, the target must offer a more substantial reward than anything within the grasp of a single animal. Birds are not as physically robust as terrestrial

animals and will not usually target prey larger than themselves, so the cost of sharing normally exceeds the benefit of hunting as a group. It is possible to imagine scenarios in which cooperation would pay off for some bird species, but evolution has no imagination and cannot plan ahead.

Christine Warman

Hinderwell, North Yorkshire, UK

This week's questions

WHO NOSE?

We're told cancer is prevalent in tissues that regularly regrow, such as intestinal and skin cells. I recently read about Darek Fidyka, the paralysed man who received pioneering surgery to restore the use of his legs by implanting olfactory cells from his nose (which regularly divide) into his spinal cord. It made me wonder: why is nose cancer not a common occurrence, because these tissues constantly regrow?

Stuart Watts

Glasgow, UK

POULTRY QUESTION

Are we making the threat of avian flu worse by killing infected birds? Would it make more sense to isolate them and let them develop immunity naturally? Or is bird flu so serious that they would all die anyway?

Richard Hind

York, UK

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